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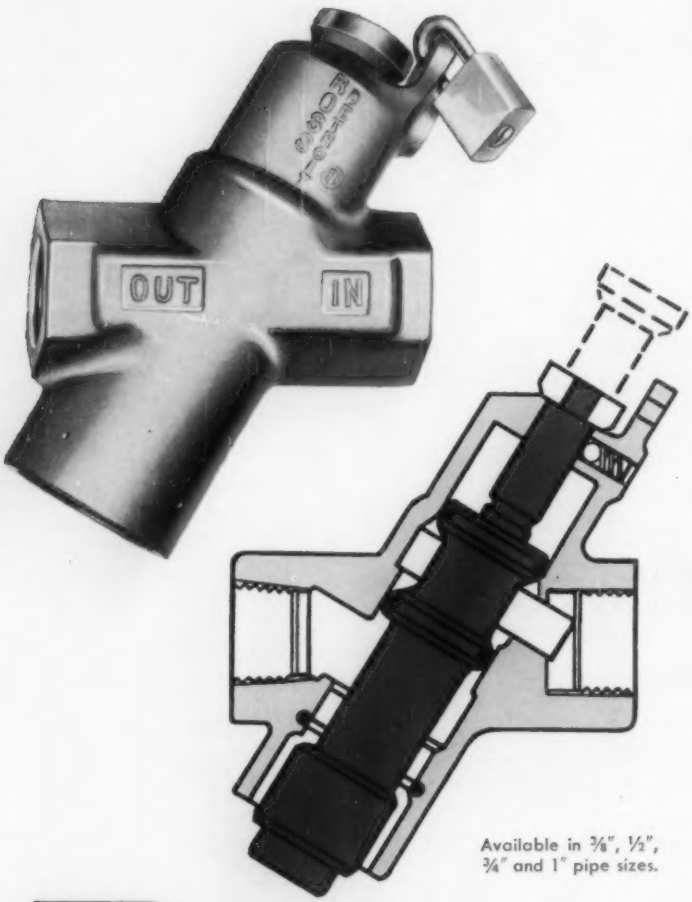
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · JULY 25, 1960

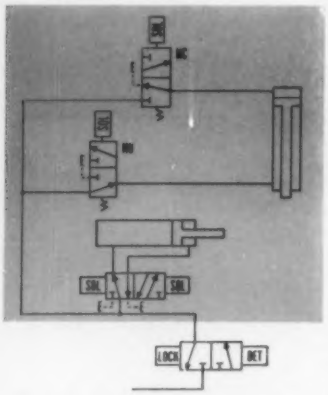
Key figures in calculator design . . . *see page 3*

Lock out air for machine repair

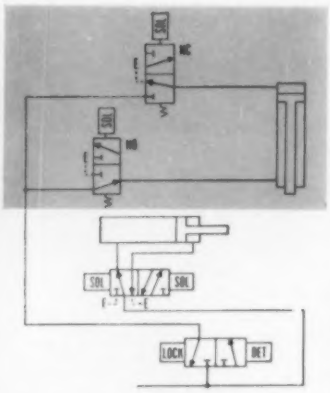


Available in ⅜", ½", ¾" and 1" pipe sizes.

(AIR LOCKED OUT FROM SHADED AREA OF CIRCUIT)



Use the L-O-X valve to shut down an entire air circuit . . .



. . . or use it to shut down just a portion of the circuit.

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More L-O-X valves can be incorporated in the circuit to shut off and exhaust various segments of the circuit. Thus portions of the circuit can be available for maintenance service without shutting down the entire circuit. Detented in the open position, designed for very low pressure drop. Lightweight aluminum construction. Call your Ross representative or write for literature.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

July 25, 1960 Vol. 31, No. 30

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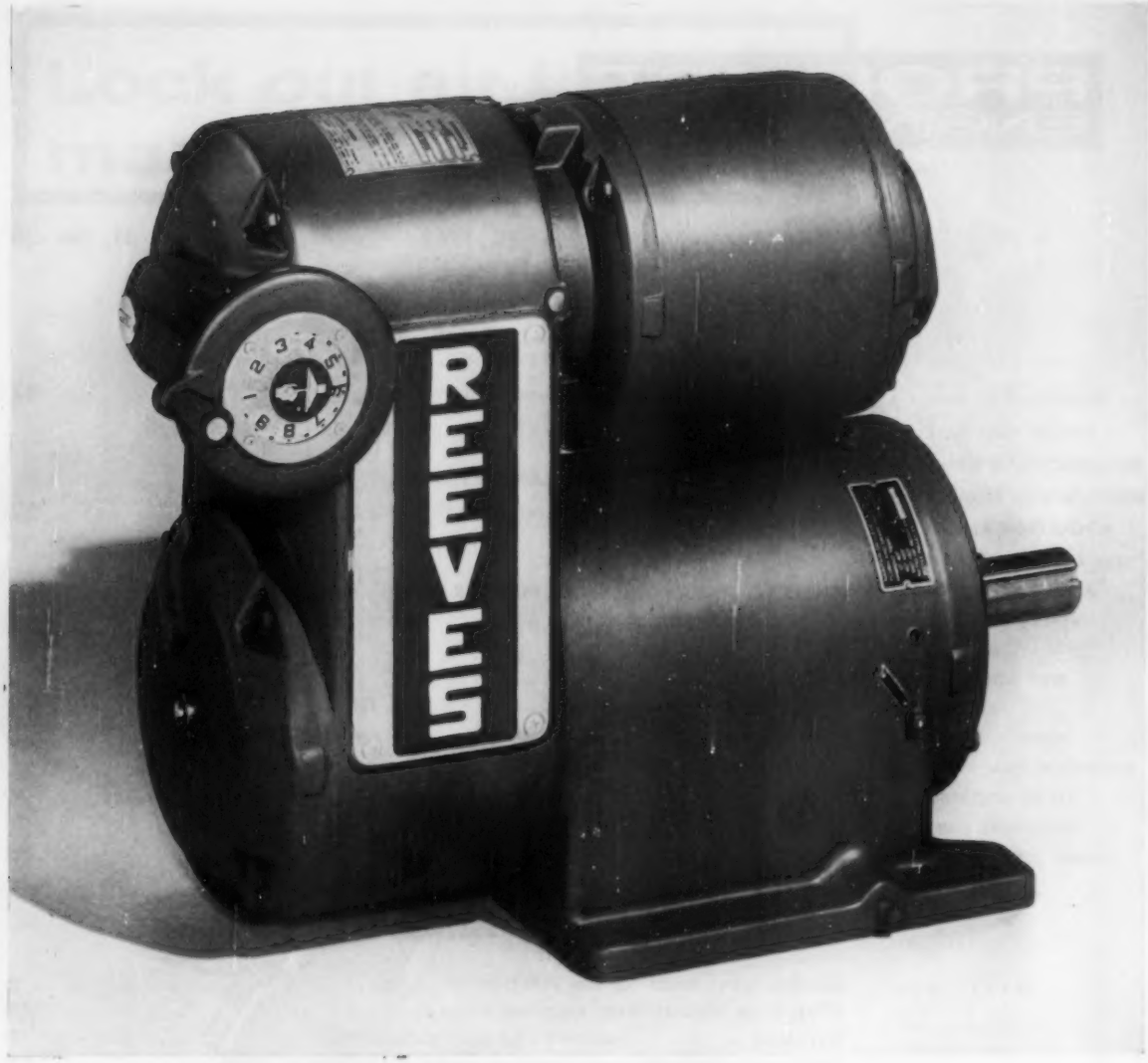

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INTERESTING TO NOTE

On our cover–the project team responsible for developing Marchant's latest calculating machine, the "Transflo." The last word in automatic electric desk calculators, "Transflo" (in the foreground) speeds problem-solving by transferring figures from dial to dial. It is a product of the Marchant Div of Smith-Corona Marchant Inc, of Oakland, Calif.

In the photo are John D. Kemper, vice-president–engineering, seated at right; and B. B. Tippin, chief project engineer, standing immediately behind him. Next is Harry F. Noller, project engineer, who spearheaded the "Transflo" project. Two members of New Products Research are seated at the far end of the table, Walter E. Mathi (right) and Eugene E. Reynolds. The four design engineers on the project, seated to the left are (counterclockwise): Charles G. Schneider, Lester E. Diethart, Paul B. Kiilsgaard, Harry A. Mueller.

Focal feature of the new calculator is its back-transfer mechanism. Although requiring only one control key on the keyboard, the mechanism had to have hundreds of additional parts. A single touch of this key clears all dials and transfers the figures from any 10 consecutive lower carriage dials to the keyboard dials in direct alignment, ready for use as the next factor in a problem of division, multiplication, subtraction or addition.

"Transflo" is latest achievement in Marchant's half-century in business. It started the American calculating-machine industry in 1910 when four Marchant brothers joined efforts to produce the first calculating machine manufactured in the United States for commercial use. This early lever-set machine, the "Standard," stands behind the "Transflo."

In the display case on the top row, left, is the "Speedster," a faster, more compact version of the 1910 "Standard." It made extensive use of aluminum in construction. Center is the world's first electrically powered calculator, developed by Marchant in 1915.

At the right is the 1933 "Silent Speed" model, the first machine to utilize the principle of constantly meshed, proportional gears. Since 1933, all Marchant calculators have used the proportional-gear mechanism, which makes them the world's fastest desk calculators.

continued, page 4

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On the bottom row, left, is the 1923 KE model, the first electrified full-keyboard calculator. The "Figuremaster" model is on the right. This calculator, when introduced in 1948, radically changed the industry's concept of business-machine design with smooth, flowing contours and harmonizing colors. This type of calculator design has been accepted throughout the world.

The center machine, bottom row, is one of several gold-plated calculators prepared for display during 1960, Marchant's Golden Anniversary Year.

Check on It

How many times has the common family squabble over the checking account ended with the wife claiming, "I'm not overdrawn; you're just underdeposited"? Nothing is more infuriating to the precise, closely watched budget than that letter from the local bank. And now, with automatic check-sorters (see p 49), banks will be able to mail their overdrawn notices even quicker. Three out of every five of us have checking accounts, and last year we wrote nearly 10 billion checks worth better than three trillion dollars.

The Romans are generally credited with the invention of the check, which usually took the form of a scrawled memo to a banker authorizing the transfer of funds to creditors. Until the invention of printing, check writers were forced to do as the Romans did, but in 1672 the first printed checks were issued by the House of Child in London. In 1891, an American businessman returning from Europe complained about the time and trouble required to get cash against letters of credit. The man was J. C. Fargo, then president of American Express. Other travelers had the same problem, he felt, so he asked one of his aides to figure out a solution. The result was the now familiar Travelers Cheque.

—Benedict A. Leerburger Jr

SIDELIGHT

Recently a press release crossed our desk stating that three years ago the people of Tulsa, Okla dug up the front lawn of their county courthouse and planted a new 1957 Plymouth. They don't expect to grow a crop of Valiants, it's a publicity stunt in celebration of the 50th anniversary of the state's entry into the union. The car will remain buried for half a century, then dug up and bestowed upon the heirs of the person who, in 1957, came closest to guessing Tulsa's 2007 population. Wonder how automotive engineers feel about designing cars for underground storage?

NEXT WEEK IN PRODUCT ENGINEERING

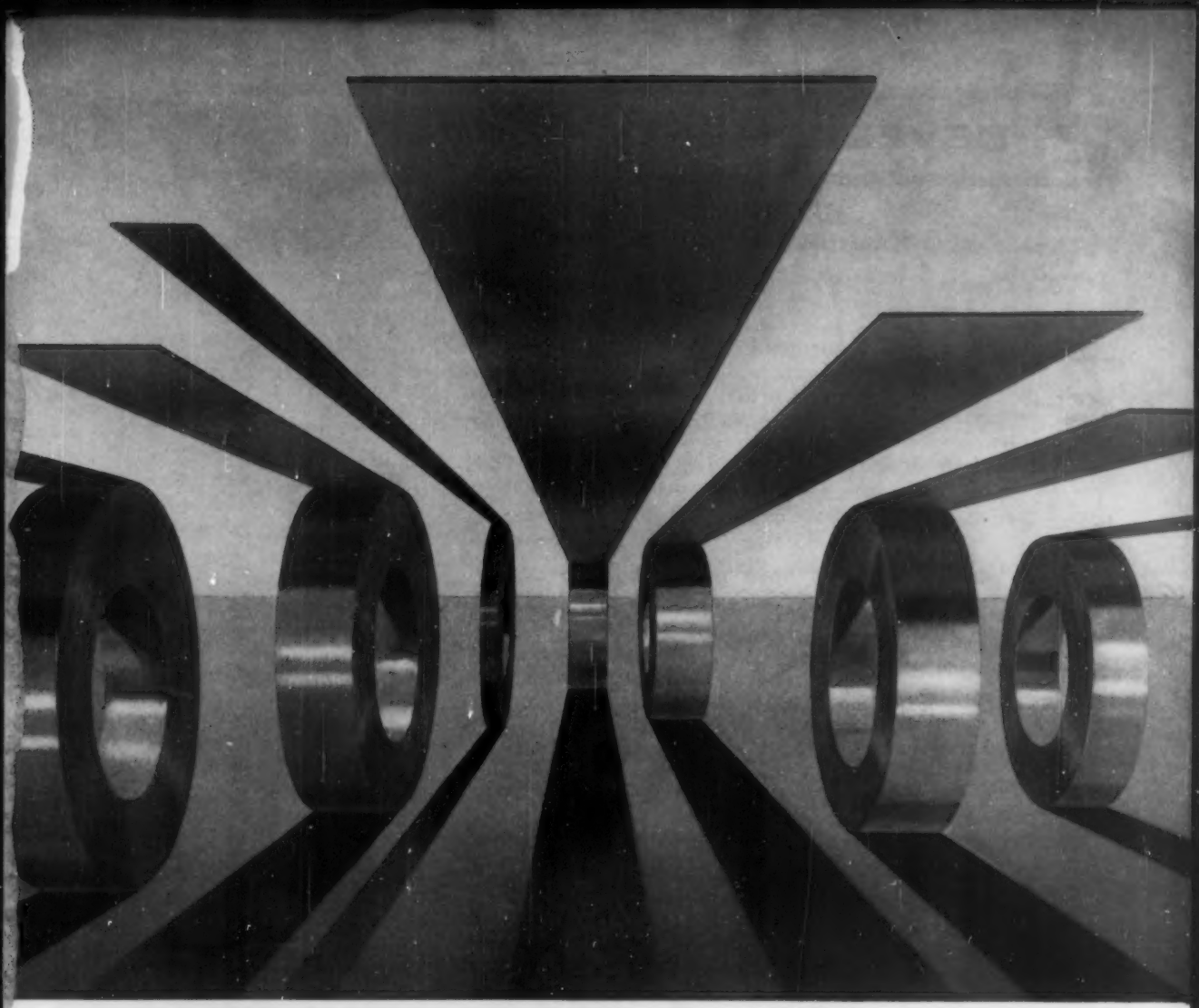
. . . **Journal-bearing Design**
A new procedure and design chart give greater accuracy than conventional methods.

. . . **How to Write Standard Operating Procedures**
If properly prepared, all those repetitive tasks—from preparing reports to ordering paper clips—will be done with minimum time and effort.

. . . **6 Ways to Prevent Overloading**
These "safety valves" give way if machinery jams, thus preventing serious damage.

. . . **When Does Automation in Consumer Products Go Too Far?**
Four experts present their points of view.

. . . **Ten Ways to Keep a Piston From Rotating**
Among them is the author's invention—V-groove ball race inside cylinder.



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DEVELOPMENTS TO WATCH . . .

Silicone lubes head for the 700-F level

Copper phthalocyanine, ferric oxide and other oxidation inhibitors can extend, by three to five times, the useful life in air at 450 to 700 F of commercially available silicone greases, Naval Research Lab reports.

Conventional inhibitors like phenylalphanaphthylamine and dilauryl selenide are also effective in the 480 to 570-F range, but have relatively little value above that.

Concludes NBS: The improvements achieved with these additives indicate silicone lubricants with acceptable viscosity and stability at least over the range from −65 F to 580 F can now be formulated for commercial production.

An interim report on the work is now being prepared for publication. It will be NRL Report 5457, and should be available from OTS, Dept of Commerce, Washington 25, DC in about a month. It will be PB161314, priced at 75¢.

New "plastic" magnets have higher holding power

Rubber-bonded magnets with a maximum energy product (BHmax) of 2×10^6 gauss-oersteds (as compared to 0.9×10^6 for today's flexible magnetic materials made with nonoriented magnetic particles) are being readied for introduction by Leyman Corp's Magnetics Div. These are ferrite-bearing materials (lead, strontium, and barium compositions may be used) with a coercive force on the order of 1300 oersteds and a residual induction of 2100 gauss. Top operating temperature (no-load) is about 200 F. Specific gravity is about 3.7. The material is readily machinable, can be die-cut before vulcanization.

Redundancy to play bigger role in system design

Duplication of components as a means of increasing reliability has not been in good repute because of its penalties in size and cost. But, says Tung-Sol Electric's Semiconductor Div, miniaturization has now reduced the size of many components, "to the point where duplication of parts no longer creates a significant increase in size-weight factors." It is now feasible, Tung-Sol believes, to consider redundancy as a standard technique for increasing reliability in system design.

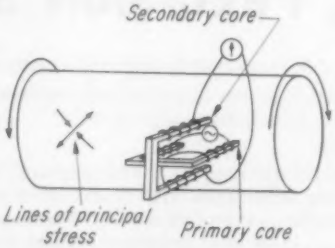
Applications are still in their formative stages, but Tung-Sol engineers believe redundant systems will be used in many future designs to indicate and override as well as to prevent failure.

Note: For a full-dress report on reliability, see *PE*—May 16, p 65.

New torque gage designed in Sweden

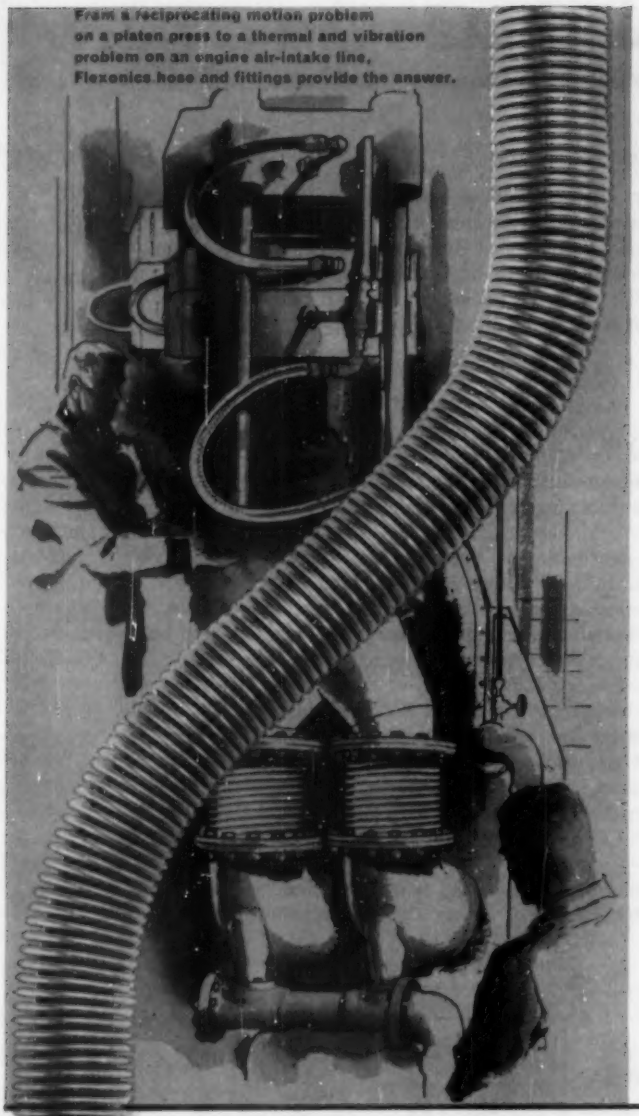
A torque gage without slip rings has been designed by ASEA, Vasteras, Sweden. It measures the changes in permeability of a shaft at 45° to its axis, and induces a proportionate output voltage that is sufficient, without amplification, to operate indicators and recorders.

The gage takes advantage of the fact that the permeability of a steel shaft is increased in one direction and decreased in the other in proportion to the applied torque.



BASIC PRINCIPLE OF TORQUE GAGE is indicated here. This is the cross torductor.

The unit consists, (see diagram) of two U-shaped, laminated-iron cores mounted at right angles to each other in a measuring head. The measuring head is placed adjacent to the shaft with one core parallel to the axis of the shaft. There is an airgap of about 0.1 in. between the shaft and the poles of the two iron cores. A new ring-type unit, now under development, completely surrounds the shaft and provides even more accurate measurements.—ARG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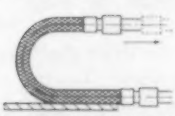
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IH-385

New electrolytes may signal battery improvements

Nickel-cadmium storage batteries that use cesium and rubidium hydroxides in place of the conventional potassium hydroxide electrolyte are to be built and tested by the Special Purpose Battery Branch, US Army Signal Research & Development Laboratory. The aim: development of units with improved high-temperature charge retention and low-temperature performance. The work is still in its early stages, but the laboratory expects to have sufficient data in about three months to permit evaluation of the new electrolytes.

Thermoelectric cooling coming—but not yet

Despite its many advantages, thermoelectric refrigeration is not likely to be competitive with mechanical systems in major appliances and air conditioning for some time to come.

Thermoelectric units offer opportunities to eliminate moving parts, reduce noise, simplify electric wiring, and provide for reverse cycling. They may well be competitive for specialty items—particularly where design capacity requirements are low (under 200 btu/hr). But even assuming a cost for thermoelectric materials well below the present price (22¢/gm), these direct energy converters can't compete in the larger sizes.

That's the conclusion from a major cost study by D. W. Scofield, P. F. Taylor, and L. A. Staebler of Philco's Appliance Div, as reported to the ASHRAE.

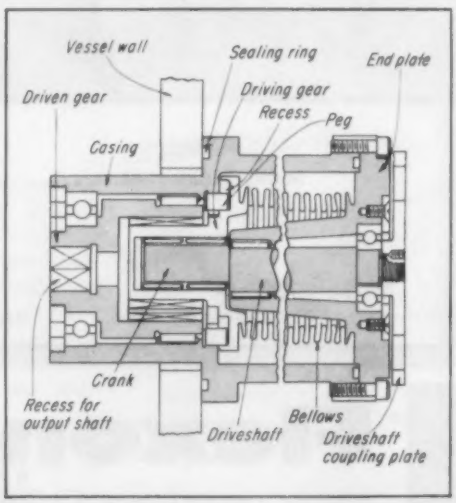
"If significant improvements are made in the figure of merit for thermoelectric materials," they say, "or in thermocouple fabrication, either of which will permit the use of less thermoelectric material for the same performance, then thermoelectricity will become more competitive." Use of dc power supplies might also permit significant cost reductions.

The outlook for military applications, though, and for small commercial refrigerators (up to 4 cu ft) is very bright, they believe.

British claim new sealed drive

A drive transmission for closed systems that permits speed ratios other than 1:1 is claimed by the UK Atomic Energy Authority. To transmit motion without a gland and without an oblique pin-and-diaphragm combination or magnetic coupling, the British use a crank attached to the drive shaft, which moves a gear wheel. The internal gears on the wheel engage the external gears on the output shaft.

In this respect, it is similar to the harmonic drive (PE—Dec 9, '57, p 9 and Feb 8, '60, p 47). However, the gears are round and not elliptical and British system uses a bellows as well as the crank-gear system to prevent backflow of fluid. Such gear ratios as 23:3 can be obtained, with an output torque of 100 lb-ft.—ARG



CRANK-GEAR SYSTEM is used for transmission of rotary motion through wall of a closed system. Bellows helps prevent leakage in this British design. Peg-and-recess device keeps drive-wheel from rotating in relation to casing.

WHAT'S HAPPENING IN RESEARCH . . .

Fillers help plastics resist electrical failure

Look to the filler, says G. L. Sommerman of Westinghouse, if you want to reduce electrical surface tracking and erosion in plastics.

A 4-year study of thermoplastic dielectrics, elastomeric casting resins, and encapsulating compounds shows chlorinated polyesters, polyvinyl chloride, epoxies and polycarbonate (in that order) have the best wet-tracking resistance; while the rubbery materials (butyl, polyethylene, acrylic, polypropylene and polytetrafluoroethylene) tend to fail by erosion.

However, says Sommerman in a detailed report to the AIEE, "the addition of large amounts of hydrated fillers (hydrated alumina, for instance), greatly improves the tracking resistance (both wet and dry) of such polymers as butyl rubber, epoxy resins, and some, but not all, polyester resins and elastomers. In fact, the formation of conducting-surface tracks may be eliminated entirely in such polymers if sufficient hydrated filler is used."

One point not covered in this report: the effect of such large filler additions on other physical and mechanical properties.

Roughened surfaces improve heat transfer

Stainless steel tubes with knurled and threaded surfaces outlast smooth-surfaced tubes by factors as high as 2:1 in high-pressure hot-water systems, says a recent AEC report, prepared by General Nuclear Engineering.

The tests (made in Europe—not under GNE or AEC sponsorship) showed a ratio of heat flux in diamond-knurled tubes of 1.5:1 to 2.1:1 as compared to smooth tubes; 1.6:1 in tubes with 30 threads/in. (0.006- in. deep) and 1.8:1 in tubes with 64 threads/in. (0.009-in. deep). Longitudinally knurled tubes showed the lowest ratio: 1.35:1 and also caused difficulty through severe vibration during the test.

As to friction factor of roughened vs smooth tubes, the coarsest diamond knurl (0.008-in. deep) showed the lowest ratio: 1.6:1; while the fine diamond knurl (0.013 in. deep) had the highest: 2.8:1. Also of interest was the fact that roughening of graphite disks was found to increase their critical heat flux by as much as 30%.

New alloy to boost reactor efficiency

Reactors that operate at higher temperatures with increased efficiency will be one result of zirconium alloys research programs now under way.

That's the prediction of John H. Schemel, Carborundum metallurgical engineer.

Recent tests of a Zr-Cu-Mo alloy developed in England show it to have greater mechanical strength and heat resistance and "vastly improved corrosion resistance" as compared with the Zircaloys, Carborundum says. And, in addition, Schemel reports, there is promise of marked improvement in properties by new heat treatment methods.

Nuclear properties of the new alloy are similar to those of Zircaloy 2; but mechanical properties at elevated temperature—even in the annealed state—are considerably better. At 600 F, for instance, Zircaloy 2 has a tensile strength of about 30,000 psi; the new ternary alloy is at least 15% better. Likewise, time to reach a strain of 1% is less than 10 hr for Zircaloy 2; about 900 hr for the newer alloy.

Test data and material for evaluation may be obtained from Carborundum Metals Co, Akron, NY.

Rubidium for new instruments and heat exchangers

An element that's been known for nearly 100 years, but still rates as an "unknown," is taking on new importance these days. It's rubidium, element 37, and one of the alkali or alkaline-earth group that includes lithium, potassium, and cesium.

Primary attention-getter of rubidium's new applications is its potential in space vehicles where the ease with which it can be ionized (separated into charged fragments) makes it one of the best space "fuels" (*PE*—Sep 23 '57, p 17 and Oct 7 '59, p 15). Ease of ionization also opens possibilities for its application in energy-conversion devices like the plasma thermocouple (*PE*—Dec 1 '58, p 10). It's being tested, too, as a heat-exchange medium in small nuclear power systems; and, the Bureau of Mines reports, a rubidium boiler has been tested for generating electricity from conventional power sources.

Rubidium shows promise for more prosaic applications as well:

It is being used as a "getter" in vacuum tubes.

In a new magnetometer, strength of magnetic fields is measured by the reaction of rubidium vapor to light.

The device takes advantage of the fact that the absorption of light by vaporized rubidium is affected by magnetic fields.

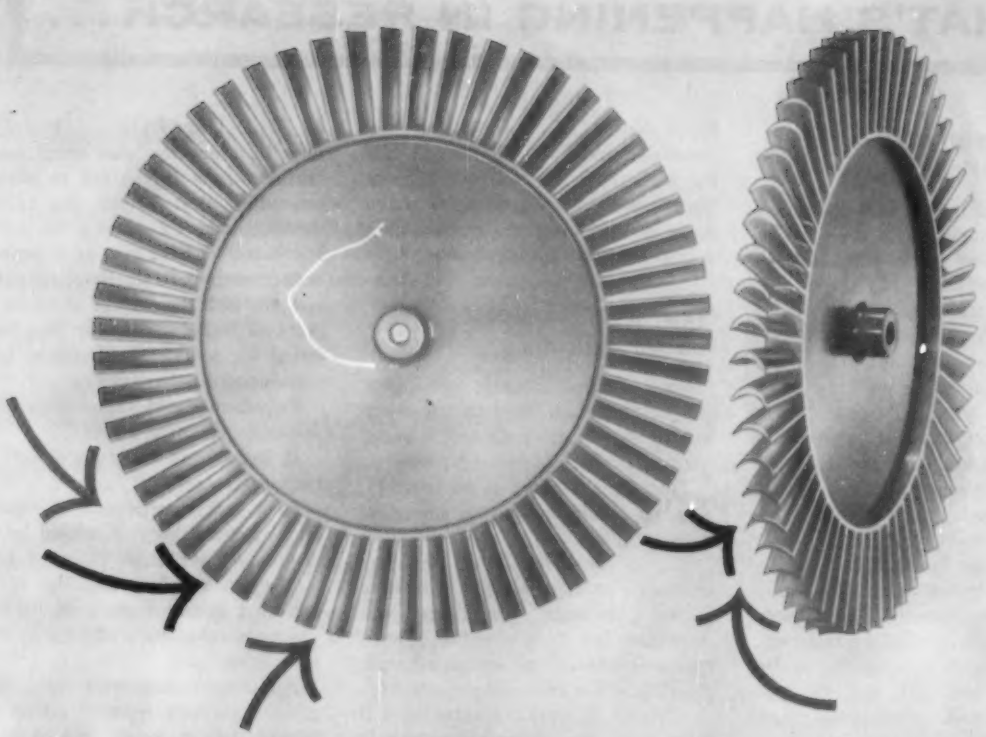
Rubidium compounds, too, show promise for new types of glasses and piezoelectric materials, as well as for battery electrolytes (see p 8).

briefs . . .

Teflon-coated thrust bearings give superior performance in load tests, the Bureau of Ships says. But to protect the plastic, oil grooves must be omitted from both mating surfaces. The reason: grooves tend to act as scrapers, removing the plastic, and also collect foreign particles that act as starting points for film breakdown.

Under BuShips sponsorship, a wide range of bearing materials is being tested in an effort to improve efficiency of controllable-pitch propellers. Most promising combination found so far is a lead-particle-impregnated bronze bearing with a chrome-alloy-coated mild steel plate. The plastic coating is applied to the bushing in a thickness of about 2 mils.

Leather made like paper, by dissolving hides and using collagen fibers so obtained to form homogeneous, uniform sheet materials, is promised by a joint Armour–United Shoe research program. The process is still in the laboratory stage; but is expected to prove competitive with presently used tanning processes. —ARG



More power to Sunbeam vacuum cleaners with this Chicago Molded turbine fan

One of the principal features of the new Sunbeam "Dual De-Luxe" Vacuum Cleaner is the turbine brush. This brush is driven by a unique one-piece turbine fan wheel molded of Nylon. It is believed to be the first plastic single piece molding of a fan incorporating the turbine principle. The fan wheel is made up of 56 curved blades, so spaced as to allow for intake of paper clips, hairpins and similar objects. Nylon was selected for its flexibility and resistance to this metallic impact.

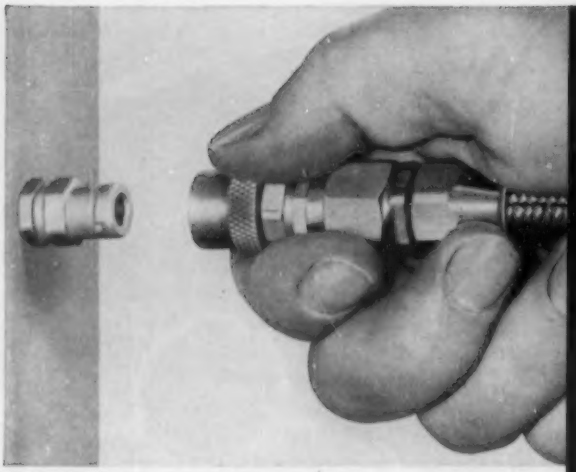
Obviously, this intricate piece presented molding problems. Engineers of Sunbeam and Chicago Molded worked closely together. The answer was a most unusual and complex mold incorporating 56 individual sliding side cores, one for each blade.

Once again the broad experience of Chicago Molded, their knowledge of materials and methods, and their mold-making skill, have combined to lick a tough problem. These important advantages are yours when you deal with CMPC. Why not talk things over with us? Just write or phone. There's no obligation.

See Sweet's Product Design File 2c/Ch, or send for new brochure "Design and Purchase of Custom Molded Plastics."

CMPC

CHICAGO MOLDED PRODUCTS CORPORATION
1020 D North Kolmar Avenue
Chicago 51, Illinois



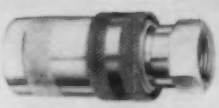
This miniaturized Self-Sealing Coupling on an Aeroquip Teflon Hose Line assures fast, leak-proof connections on the coolant system of an electronic unit.

Aeroquip's Wide Range Of Self-Sealing Couplings Improves Connections On Any Fluid System

Aeroquip has developed hundreds of Self-Sealing Couplings for standard and specialized applications. Whatever your requirements, there's an Aeroquip Coupling, or a modification, which will provide better fluid line connections and disconnections.

For assistance in solving special problems, Aeroquip's large and long-experienced Engineering Staff is at your service. Mail the coupon below for information.

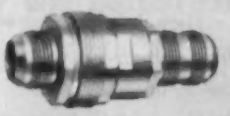
5600 Series PUSH-PULL Coupling provides quick connections on hydraulic, lube oil, air and water lines. It is available for ⅛" to 1" hose lines at working pressures up to 3000 psi.

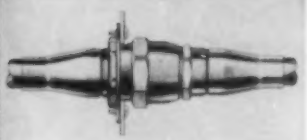


5100 Series Threaded Coupling for a wide range of applications where connection under pressure is required. Available for ¼" to 2" hose lines with pressures to 3000 psi., depending on size.

1010 Series Miniaturized Coupling is designed for connections in confined areas. Precision-built, lightweight (.037 lbs.) and compact, it fits ¼" O.D. tube size.

3900 Series PUSH-PULL Coupling combines leak-proof operation with quick, easy connections. Available in sizes up to 1½", it may be used with many low lubricity fluids.





5500 Series Refrigerant Coupling permits precharging and storage of components for remote package units. It is available in sizes from ¼" to 1⅛" O.D. tube sizes.

5400 Series Refrigerant Coupling simplifies assembly line installation of precharged automotive air conditioning systems. Available in O.D. tube sizes from ¼" to 1⅛".

Series 5900 QUICK-LOADER Marine Coupling connects and disconnects quickly to provide fast transfer of liquid cargo without spillage. Sizes for 6" to 12" lines.

Series 510038 Railroad Coupling for Aeroquip Automatic Fueling Unit eliminates fuel spillage or overflow. Coupling feeds fuel quickly, float attachment for automatic shut-off available.

QUICKLOADER and PUSH-PULL are Aeroquip Trademarks.

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REPORT FROM ABROAD . . .

Computers to the east, computers to the west

Electrotechnical Laboratory of Japan—that nation's version of our National Bureau of Standards—has begun constructing a computer reported comparable to IBM's Stretch, Remington's Lark, and the new units being built at Univ of Illinois and elsewhere. And Redifon Ltd, Crawley, Sussex, Eng, is ready to introduce a general-purpose computing and data-handling unit which combines analog and digital computing techniques in a single system.

ETL reports total R & D cost of its computer will be a surprisingly low $236,000, says it will be completed by this fall. Arithmetic speed is expected to be 0.5 microsec for fixed-decimal-point addition, 1.5 microsec for floating-decimal-point addition, and 5 microsec for multiplication. Dr Shigeru Takahashi of ETL says that 0.2-microsec-cycle Esaki diodes will be used in the supplementary memory unit.

The British computer is specifically developed to take advantage of the convenient input/output equipment and extensive storage facilities of the digital machine with the speed of operation, ease of programing and low cost of analog equipment. Cost is reported to be as low as $30,000.

EPA plans research-spending study

How much are European countries spending for research? The European Productivity Agency's Committee on Applied Research hopes to come up with an answer within the next year.

First step, says CAR, is to extract from the maze of European currencies, and different concepts of where research ends and development begins, a common yardstick for reporting expenditures. CAR hopes the yardstick will be ready by fall.

Next step is to get a questionnaire out to member governments of the Organization for European Economic Cooperation (OEEC) by year's end. Idea behind the study is to spur more research spending by these governments. They also hope to find what financial inducements are being offered by governments to companies that finance research.

Meanwhile, the German government intends to cut its financial aid to research work. Reason given is that industry and local governments should carry a larger portion of the load. Bonn will probably slash the $15.1 million made available this year to $10 million.

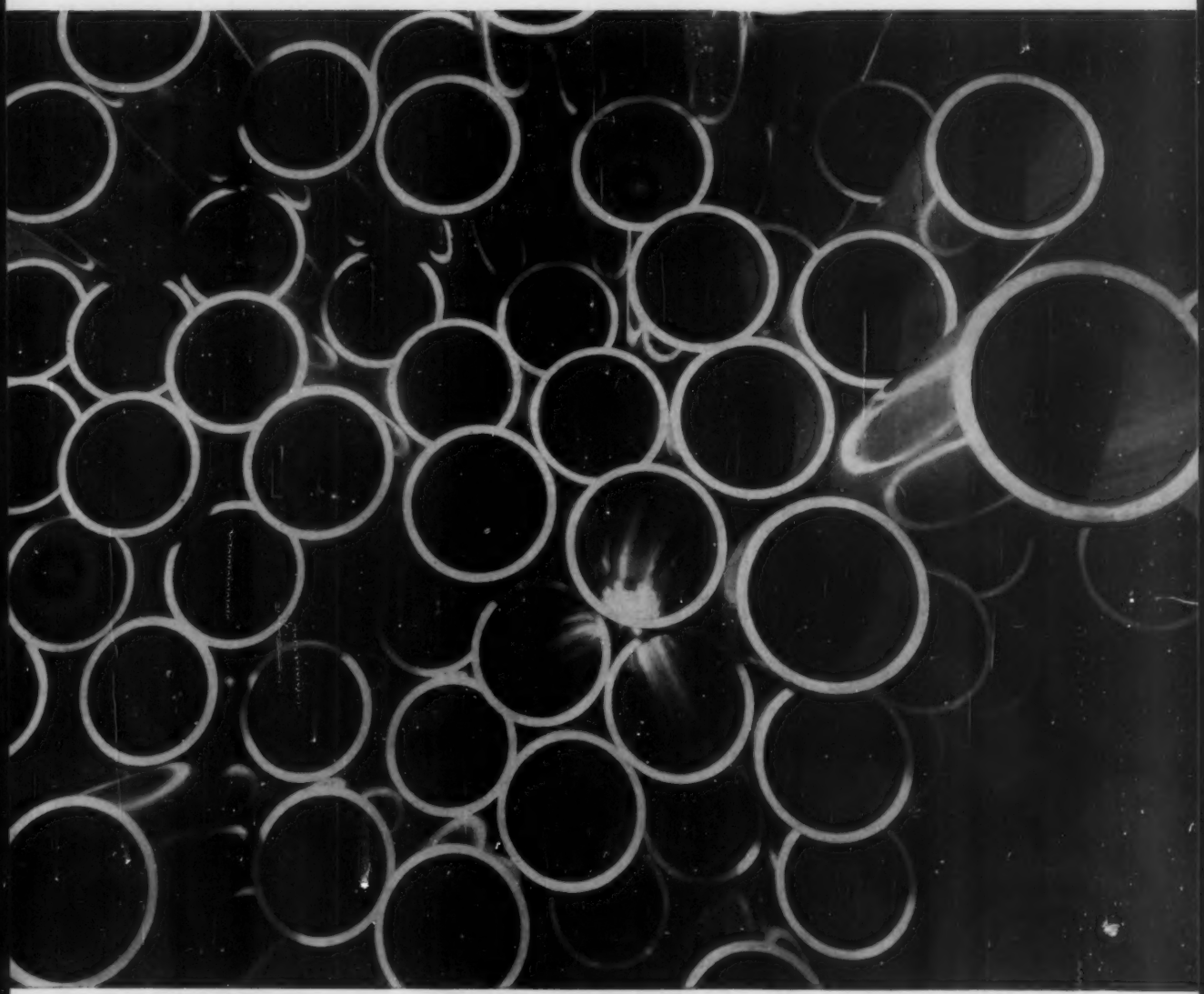
Industry, which is directly benefited by this funding, says Bonn, donated only $1.3 million last year to basic and applied research. Local governments had already indicated they hoped to up their $2-million donation last year to $2½ million this year. Industry has made no comment.

Industrial design changing in Italy

A revolution may be in the making in Italy's industrial design circle although many believe it will be an evolution. It's a trend away from using industrial design as a means to correct or embellish the form of a product through the sensitivity of a single manager or designer. Sole ownership is disappearing and management is becoming more aware of the industrial designer as the limited Italian market expands and catches up to demand.

Italian industry realizes the importance of good design in competing for world markets. One step towards this may be a new school of industrial design sponsored partly by industry. The "Compasso D'Oro" prize for 1959 being given to the British Council of Industrial Design rather than to one of the many Italian designers was a severe blow and may be one reason for the change at this time. Some Italian designers hope the move is not too late.

This mark tells you a product is made of modern, dependable Steel.



Look at the dimensional accuracy and smoothness

You can reduce the costs and processing time of parts-making by using USS National Electric-Resistance Welded Mechanical Tubing. It eliminates drilling operations. It lets you replace drills with simple, less expensive boring tools. Mechanical Tubing reduces tool wear and tool changes.

USS National Electric Welded Mechanical Tubing is an ideal load-carrying member. It resists bending stresses equally in all directions and gives you a superior cross section. It absorbs and localizes shock. In torsion, it provides better material distribution. And for a given weight, mechanical tubing withstands more load than other sections.

USS National Electric Welded Mechanical Tubing is available in cold-drawn or hot-rolled sizes ⅜″ thru 5½″ and in wall thicknesses .035″ to .250″. It can be obtained from National Tube Distributors located throughout the country. They will gladly show you how to use USS National Welded Mechanical Tubing in your next application. *See your USS National Tube Distributor.*

USS and National are registered trademarks

National Tube Division of United States Steel

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RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

No difference between hex and cap screws

It's not the *name* of a standard fastener that determines whether to use it for a particular application, but vice versa. The *application* requirements for strength and tolerances dictate the fastener.

Thus, if you have a joint that calls for certain tolerances in a screw, obviously the one which satisfies those tolerances is the right fastener.

IDENTICAL STANDARDS

In the case of cap screws and hex screws, the standards will show you that these are merely different names for the same product. They're actually made on the same machines, to identical tolerances, and from identical materials.

No reason then to differentiate. For tapped holes, merely specify Hex Screws (SAE Grade 2) or High Strength Hex Screws (SAE Grade 5), and you'll get the *right* fastener with the quality needed.

For bolted joints, these same items are supplied with nuts when specified.

This should suggest a way you can extend standardization in your plant . . . and benefit from our new simplification of nomenclature which calls *any* fastener with head on one end and threads on the other a *screw;* and a screw plus nut a *bolt.*

See how "holding power" can cut fastener costs

SIZE	SAE GRADE	SAE PROOF LOAD	COST RATIO
3/4"	Gr. 5	28,400 lbs.	100%
1"	Gr. 2	16,950 lbs.	188%
1 1/8"	Gr. 2	21,350 lbs.	239%
1 1/4"	Gr. 2	27,100 lbs.	277%

Since the usual job of a threaded fastener is to hold an assembly tightly together, its *clamping force* is what you're really utilizing. This seems obvious. But how best to get the clamping force needed for the joint design? Not so obvious. Looking at size alone can be misleading . . . *and quite costly,* as the chart above demonstrates.

HOLDING POWER MEANS MORE THAN SIZE

SAE "proof load" of four different hex screws of standard steels, along with typical cost ratios, are compared. Almost unbelievable, isn't it? Yet it's a fact that the smallest of the group—the heat treated SAE Grade 5 *RB&W High Strength Hex Screw* exceeds all the others in load capacity. It can be used in place of any of the others in most normal usages.

Since it's smallest and therefore weighs the least, it also costs less... 64% less than the 1¼-inch grade 2 hex screw; 58% less than the 1⅛-inch; 46% less than the 1-inch. And since holes can be made smaller, there are also the savings in production drilling . . . and possibly in materials, too.

DESIGN ADVANTAGE

Remember, too, that smaller fasteners are more easily torqued to higher preload levels . . . which helps keep joints tight, makes them more vibration-proof.

If you would like to explore this approach to fastener economy and better utilization of "holding power," consult with an RB&W specialist. Let him contribute his fastener knowledge to your design and production needs. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

THE ENGINEERING WEEK

Thousands From Abroad Flock to US Seeking an Engineering Education

NEW YORK—Last year, American educational institutions enrolled 11,279 engineering students from overseas. This is about ¼ of all foreign students studying in the States. In addition, about 500 engineering students or young professionals got some practical training here under programs set up by US companies or under the exchange program of the International Association for the Exchange of Students for Technical Experience (IAESTE).

Nearly ⅓ of all foreign engineering students come from the Far East, Middle East or Latin America—areas just embarking on industrial development. A survey just completed by the Institute of International Education (IIE) indicated that 3642 engineering students from the Far East studied here during the 1959-60 academic year. This is about ¼ of all students coming from that area. In addition, 3344 Far Eastern students studied physical and natural sciences. The Near Eastern engineering contingent, numbering 2691 students, constitutes about 36% of all students coming here from that area. The Latin Americans are divided about evenly between engineering and the humanities.

MOST STUDY MECHANICAL ENGINEERING

Mechanical engineering attracts the largest number of foreign technical students (2857), but this specialty is closely followed by civil engineering with 2350 enrollees. Civil engineering is particularly attractive to students from Iran and India—countries with large construction projects underway.

Most engineering students (about 70%) are on the undergraduate level, and most of these are probably self-supporting. The survey finds that roughly ¾ of all undergrads from overseas pay their own way. About ¼ of the graduate students are self-supporting.

Despite the large number of youths studying here, administrators of scholarship and exchange programs generally agree that the US could and should offer more opportunities for foreign students to get education and training—especially in fields critical to rapid and orderly industrial and social progress in the underdeveloped countries.

Less than 10% of all foreign students in the US received full or partial support from the US government. About 3000 students were studying here last year under the Smith-Mundt and Fulbright programs, which are administered by the IIE for the State Department. These scholarship and travel awards are provided through US counterpart funds and locally owned currencies abroad.

Of far greater importance in the financing of studies for foreign students are the US colleges and universities, foundations and other private organizations which provided assistance to over 13,000 foreign students last year. Most financial aid goes to graduate students and those in special categories doing advanced academic work and research.

An increase in foreign students, coming on top of higher US enrollments, is making college administrators very selective in admitting overseas applicants. The foreign scholar is considered an asset in the classroom but must compete with US students for limited scholarships and space.

"We can't begin to place all the highly gifted students who want to study here," says Lawrence B. McFaddin of IIE's development department. "We are forced to turn down many brilliant ones. Given training, they could make powerful contributions to their country's growing industries. But often they need financial help because of currency, restrictions, or simply lack of money."

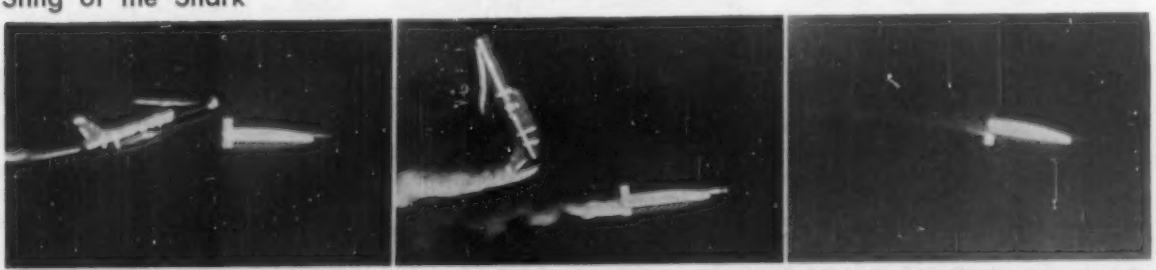
The fundamental problem, McFad-

Foreign Students—in the US
(1959–60)

	Total	All Engineering	Mechanical Engineering
Far East[1]	17,175	3642	910
Near and Middle East[2]	7110	2691	622
Europe	6362	1132	297
Latin America	9428	2520	655
North America	5761	938	281
Africa	1959	269	66
Oceania[3]	568	53	21
USSR	30	12	1
TOTAL	48,486	11,279	2857

[1] Includes China (Formosa), Japan, India, Korea.
[2] Includes Iran, Israel, Turkey, Pakistan, Jordan.
[3] Includes Australia, New Zealand and Pacific Islands.

Sting of the Snark



Sequence reveals, for the first time, the Northrop intercontinental missile releasing its jumbo-sized nosecone. Left: nosecone, containing a dummy nuclear warhead, an instant after separation from the missile. Center: nosecone streaks ahead as missile body falls away. Final photo shows nosecone traveling at supersonic speed towards target. Self-contained guidance system directs missile to target and releases nosecone at predetermined trajectory.

din adds, is that there are simply not enough scholarships even to fulfil our own needs. The US today is believed to play host to a greater number of foreign students than any other nation. Even so, the foreigners constitute only 1½% of our total student body. Roughly 18% of the students in Switzerland and 12% in Britain come from outside their borders. As for the inevitable comparison with the USSR, McFaddin says, we seem to be educating more foreign students than does Russia—and most of hers apparently come from the Communist bloc. (Moscow has announced a University for Friendship of Peoples opening next October. For foreign students only, the school will train engineers, teachers, economists and other students recruited particularly from Asia, Africa and South America.)

PRACTICAL TRAINING FOR STUDENTS

The IAESTE exchange program got underway back in 1948 under auspices of the Imperial College of Great Britain. Under this plan, companies hire exchange students from other countries for work periods in which students get practical experience. At first, nine European countries participated in the exchange. Now 26 countries, including Tunisia, India, Ceylon, and Poland are involved. The US entered in 1955.

Students work in design departments, research labs or other appropriate industrial locations. Each participating country selects students by a screening committee composed of professors, industrialites and students. The exchange is expected to be on a one-for-one basis, but this does not always hold, particularly in the US where industry is reluctant to open jobs for IAESTE trainees.

The US role in the IAESTE program is actually quite small, according to Josef Wischeidt executive secretary of the US branch. At present we have about 98 US students working abroad, and about 68 foreign students working here. German industry provides jobs for about 1200 to 1500 students each year; Great Britain, about 900 to 1000; and Turkey, about 350.

Wischeidt attributes the relatively small US participation partially to differences in attitude toward practical training here and abroad. In Europe, he says, every engineering student is expected to have some practical training before receiving his academic degree. In the US, universities generally require no practical experience. And companies are perfectly happy to have the student concentrate on academic work. Then they give him practical training especially suited to company practices.

In addition Wischeidt says, many US companies have their own training programs for foreign engineers. These are generally limited to people who have had prior connection with the company overseas.

Wischeidt finds that the kind of training students get under IAESTE varies from country to country. In Scandinavia, the work interlude is viewed as the only opportunity a professional man will have to come in close contact with workers. Hence, student assignments are close to the production line, doing technician jobs. In Germany, the students work on drawing boards or with design groups. In Italy and Spain, the exchanges are considered young professionals who should observe rather than work. Here, exchange students generally do calculations, work on drafting boards or in laboratories.

COMPANY-SPONSORED TRAINEES

The IIE survey found that US industry was host to nearly 5000 industrial trainees last year. Over 3000 of them were on technical assignments. The IIE believes that these statistics include a large number of engineers who come here to tour plants for short periods, as well as those who actually worked on a training program.

One of the largest company-sponsored programs for overseas engineers is GM's two-year cooperative program at the GM Institute, Flint, Mich. Here employes of overseas plants, many with engineering degrees and all having some technical background, take a two-year cooperative program in mechanical, electrical or production engineering. Academic work is supplemented by practical experience. The program, began in 1945, is host this year to about 300 men from around the world. ■

AAAS Asks Scientists to Coach the Public on Scientific Issues

WASHINGTON—Scientists are being urged to step in and take an active part in public debate on such scientific issues as radiation, food additives, etc. That is what the Committee on Science in the Promotion of Human Welfare of the American Association for the Advancement of Science has recommended in a special July report.

"Scientists bear a serious and immediate responsibility to help mediate the effects of scientific progress on human welfare," this new report states. And, it adds, "We are witnessing an unprecedented growth in the scale and intensity of scientific work. This growth has been stimulated by an intense demand for the practical products of research, especially for military and industrial use. The public interest in . . . and understanding of . . . science is not commensurate with the importance that science has attained in our social structure. It cannot be said that society provides good conditions for science's proper growth."

Thus, the report states, "Science is experiencing a period of rapid but rather unbalanced growth. Basic research is poorly supported and lacks vigor and quality."

To correct this situation, the report advocates that these steps be taken by scientists:

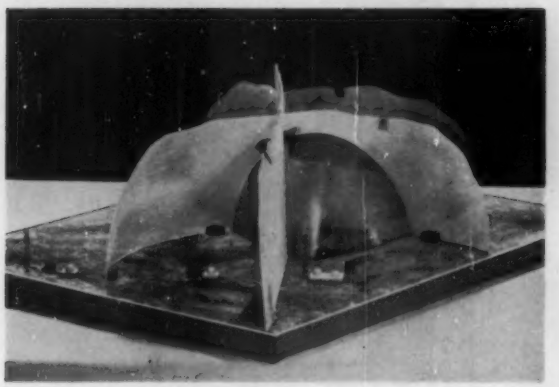
- Stimulate within the scientific community discussion of issues relating science and human welfare. This should be done through symposiums, writing articles for publication, and similar ways of reaching the public.

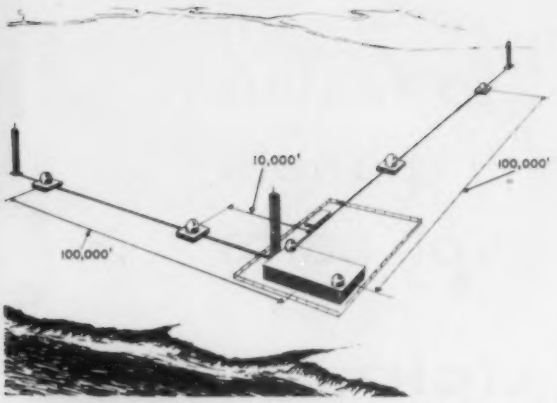
- Prepare detailed reports on important scientific issues and have them widely circulated. But the reports should be objective when recommending specific courses of action. To see that such reports are widely distributed, the report recommends that a special office be established by the AAAS to handle the job. This position has already been approved.

- Develop liaison between scientists and the public on a local basis. Greater participation in civic organizations is one way to do this, the report states. The end purpose would be to create a greater interest by the public in the understanding of scientific achievements.

Formal adoption of the recommendations of the committee is expected to come at the annual meeting of the AAAS this winter. ■

Monitor for Guided Missile Performance





A missile trajectory measurement system (MISTRAM), under development by General Electric's Defense System Dept, will monitor a missile's flight and compute its velocity, position and trajectory. Layout shows central station where baselines meet to form an "L." Remote receiving stations lie along the baseline at 10,000-ft and 100,000-ft intervals. Antennas at the five points follow the flight by signals from a beacon within the missile. The range measured by the central station, and the differences between this range and that from each remote station locate the missile in space. As shown by the model, the range measurement describes a sphere while each of the range differences describes a hyperboloid of revolution. Intersection of these surfaces in space gives the missile position, and continuous monitoring its velocity and trajectory. MISTRAM permits a reduction in system components.

Novikov Gearing Answer to Lighter, Smaller Drives

LENINGRAD—Novikov gearing is being actively pushed by the Russians even though the consensus in the US is that it offers little advantage over present gear types (*PE*—Aug 31 '59, p 21). Russian engineers believe these gears offer an immediate advantage to reduce size and weight of gear drives especially at the normal speeds and loads met, for example, in automotive transmissions.

At a conference here on "Ways and Means for Size and Weight Reduction of Gear Drives," engineers confirmed the high-load-carrying capacity of the Novikov gears, asked to see these gears introduced into industry without delay. First step to accomplish this, said a conference spokesman, is to more accurately define and then develop a uniform initial contour, and calculations, for this drive.

To reduce the size and weight of gear drives in general, the conference pointed out four areas that should be explored. These are:

- Development of more accurate methods of strength calculations.
- Increase of load-carrying capacity by application of new types of drives, such as Novikov gears, and more progressive systems.
- Use of new materials which possess or can be made to possess optimum mechanical properties.
- Application of better kinematic and design systems for gear reducers.

Engineers at the conference believe that in the next few years the production of planetary reducers would be substantially increased. These would have smaller dimensions and be lighter in weight than present units without any reduction in transmitted power. To accomplish this the following requirements have been given to the machine-tool-building industry:

- Increase quality and precision of gear-cutting machines and the production of gear-finishing machines.
- Assure the possibility of grinding gears for the Novikov gear drive.
- Develop precision cutting and finishing tools for straight and helical internal gears.

A major paper at the conference, which probably led to the order for equipment to manufacture Novikov gears, dealt with results of comparative tests of automotive gearboxes with involute and Novikov drives. Tests showed Novikov gearing to have better strength, wear and heat-dissipation properties. ■

Ford Supplements Engineering Grants

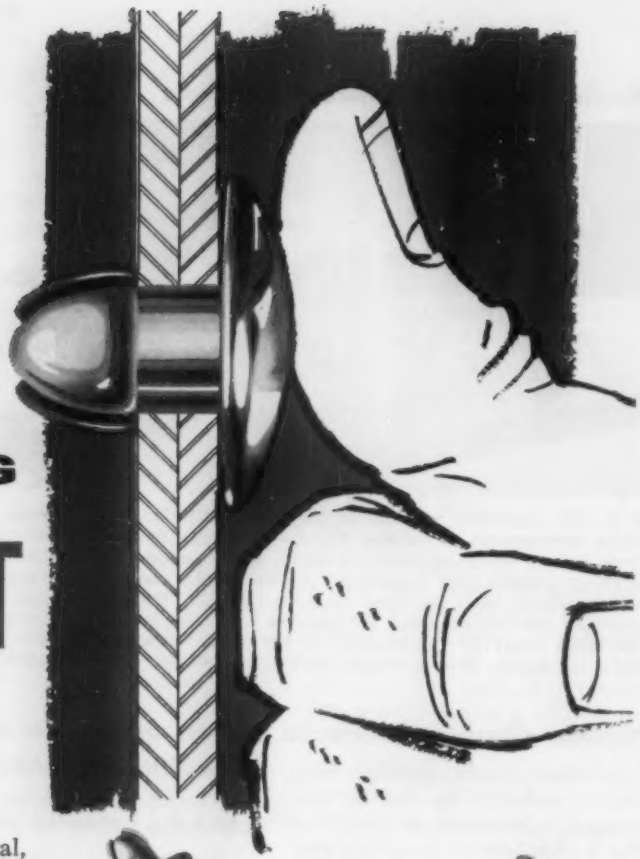
NEW YORK—Furthering its effort to advance engineering education, the Ford Foundation has granted another $6.6 million to three universities and the American Society of Engineering Education. Last year the foundation provided $19 million for educational experiments and professorial salaries (*PE*—Nov 2, p 20).

The latest grants are earmarked as follows: Stanford Univ, $3.4 million; Princeton Univ, $2.5 million; Brooklyn Polytechnic Institute, $700,000; the ASEE, $16,000.

With their grants, Stanford and Princeton will improve and expand programs at the doctoral level. Stanford will add six professors and provide for visiting professorships, released time for faculty, research equipment and graduate fellowships. The Princeton grant, in addition to providing professorships, and student aid, will include a $1-million fund for a proposed engineering-science quadrangle.

The BPI grants will go toward establishing an honors program throughout the school similar to the electrical engineering program set up two years ago. The ASEE will use its grant to survey attitudes of students toward academic careers, for members of Tau Beta Pi, honorary engineering fraternity. ■

to fasten
panels
or parts . . .



LIGHT, STRONG

TRIMOUNT STUDS

Designed for rapid assembly of sheet-metal, plastic or composite structures, Dot Trimount studs are available in both permanent and removable types. They can be pushed into drilled, stamped or molded holes by finger-pressure alone yet they lock positively in place and resist constant vibration.

Studs can be designed in steel or brass with various flange configurations for clinch, clip or clamp attachment to flexible or rigid panels as well as for push-through assembly. Available in all standard finishes . . . with or without decorative caps.

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Clinch Type Stud
Clip-on Stud
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Trim Stud Scissors Type
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Loop Type Stud
Panel Stud Staple Type
Panel Stud Hook-on Type

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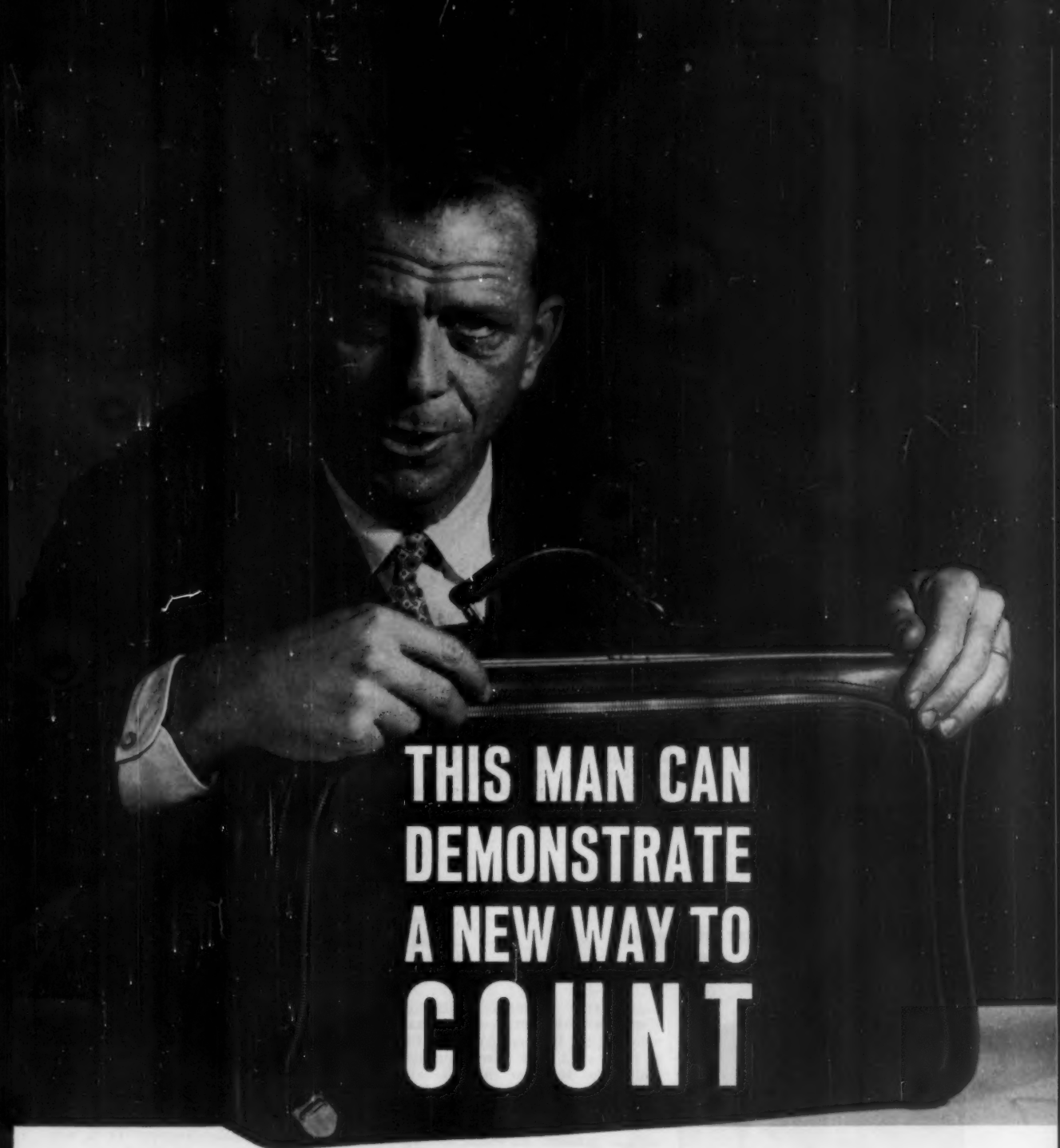

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. . . right in your own office!

Fifteen minutes of your time — that's all it'll take to put on the Veeder-Root "DESK-TOP DEMONSTRATION" — an actual performance of how Veeder-Root Electronic Counters will improve your production records, improve your product. Let us show you how Veeder-Root Electronic Counters can measure quantities, lengths, liquids; count odd-shape objects; actuate machinery; measure batches. Let us show you new counting methods utilizing Electronic Counters to count, measure, actuate — rapidly, accurately, from remote locations, with complete flexibility, with minimum maintenance.

Make sure you see the Veeder-Root "DESK-TOP DEMONSTRATION". Just call your nearby Veeder-Root branch office or write direct. Your Veeder-Root sales engineer will be glad to put on the demonstration at your convenience.

Veeder-Root

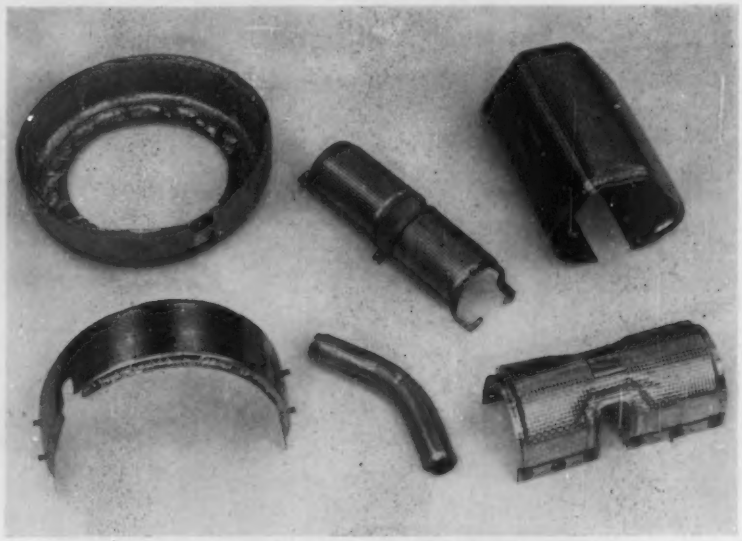
ELECTRONIC CONTROLS DIVISION
DANVERS, MASS.

"The Name that Counts"

Hartford, Conn. • New York • Chicago • Los Angeles • San Francisco • Seattle • St. Louis • Greenville, S. C. • Altoona, Pa. • Montreal • Offices and Agents in other principal cities

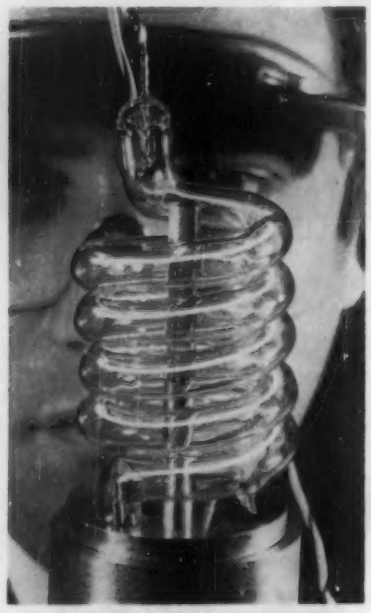
CIRCLE 19 ON READER SERVICE CARD

Lightweight Sandwich Shields Against Heat



These heat shields developed by Rogers Corp, Rogers, Conn, consist of a blanket of nonwoven refractory fibers sandwiched between inner and outer jackets of stainless steel or other high-temperature metal foils. Configuration of the heat shield is limited only by the shapes into which the foil can be formed. If the part to be thermally insulated can be enveloped in a lightgage foil, it can utilize this type shield. Production operations consist of forming the outer and inner jackets, slipping a cut-to-size insulating blanket between them, then welding and trimming edges of the jackets. The types of welding used are spot, seam and fusion. The Rogers design features an exceptionally low *K* factor and ability to withstand temperatures up to 2000 F. It can be applied to jet engines and other heat-producing equipment.

Brighter Than the Center of the Sun



Light Amplification by Stimulated Emission of Radiation (laser) as developed by Hughes Aircraft Co is a new solid-state electronic device which, for the first time, is said to give man a source of "coherent" light. This is in contrast to ordinary light sources where atoms radiate individually at random. According to Hughes, "laser" consists of a light source surrounding a rod of synthetic ruby crystal through which excited atoms generate an intense beam. Optical energy excites the atoms to a higher energy state from which the energy is radiated in a narrow band of frequencies. The atoms are coupled to an optical resonator and stimulated to emit the radiation together. The laser projects the radio spectrum to 500,000 billion cycles, which will help improve space communications and increase the number of communication channels.

Engineering Executives Hard to Find

NEW YORK—Over the next six months, recruiters in medium-size firms expect to have more difficulty finding engineering executives than any other type. This is one of the findings reported by the Executive Manpower Corp as a result of a survey among firms with average annual sales of $12.3 million.

Of the 214 companies answering the survey, 48 will be seeking engineers to fill positions in the $10,000-to-$25,000 salary range. Though the companies queried will be hiring more sales (65) and manufacturing production (49) executives, they anticipate greater problems finding the right man to fill the engineering spots.

Asked about unusual recruiting problems one respondent, from a firm with $5 million sales volume, says his company has difficulties locating "engineering executives with creative ability plus experience in our field." Another company, with $12 million sales volume is finding a "severe shortage of technical help—combination of technical and executive capabilities are practically nonexistent."

Many of the companies (102) find their executives internally. Others find them by personal recommendation (72), advertising (50), and agency or management recruiters (68). ■

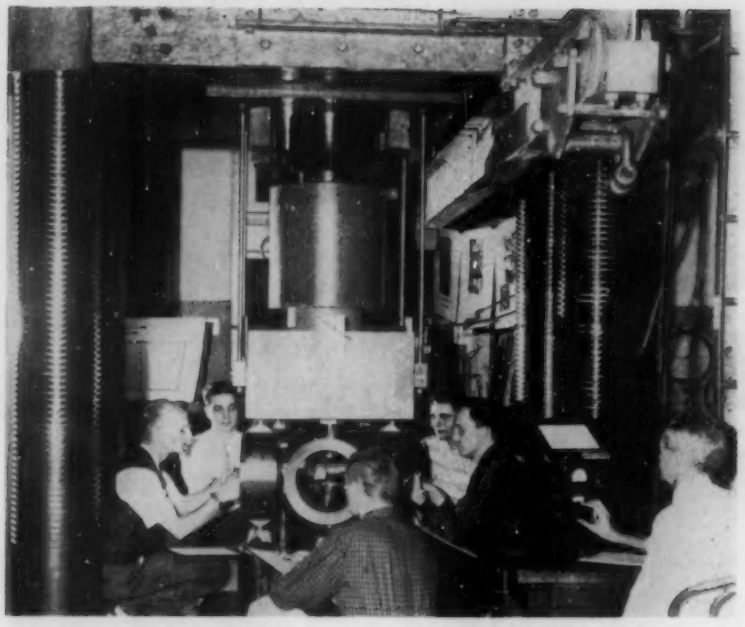
Japan Exporting Car with Unitized Frame

TOKYO—Does the unitized frame pay? A Japanese auto manufacturer thinks so. Toyota Motors is banking on unitized design to knock about 30% off the price of the car it's readying for the American market.

The car, called Toyopet Tiara, was originally scheduled to sell in the US at $2300. After the radical switch to unitized design—aimed at staying competitive with American compacts and US-imported European cars—the Tiara will sell for $1650.

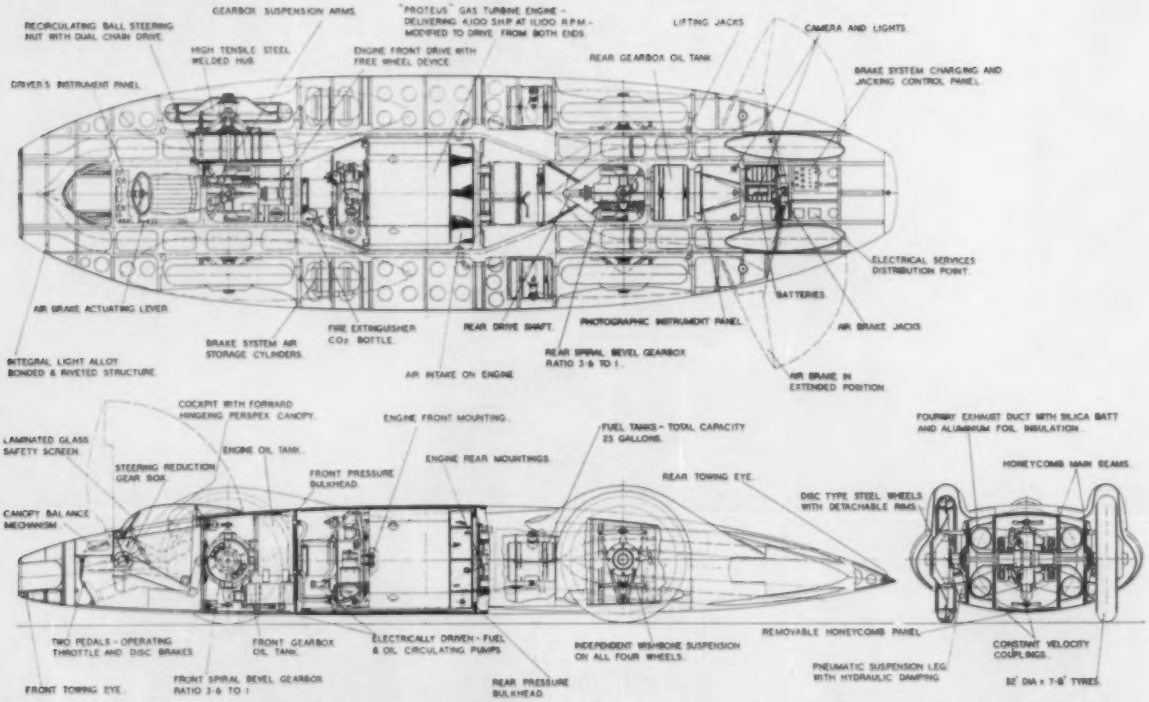
When it arrives at American dealers shortly, it will show another change—its horsepower has been stepped up from 68 to 75. This is in the hope that Tiara's handicap of slow pickup and low maximum speed can be overcome. Earlier models burned out their engines at high speed. ■

NBS Calibrates Giant Load Cell



Load cells are used to translate the load on a missile-launching stand into electrical signals which are recorded and monitored. Present units have capacities of 100,000 lb—for the Atlas, Titan and Thor, several are interconnected to give weight and thrust values. The giant cell designed by the Electronics and Instruments Div of Baldwin-Lima-Hamilton is for use with the 1.5 million-lb-thrust Rocketdyne F-1 engine. To calibrate it, NBS used five 300,000-lb-capacity proving rings acting in parallel. Each proving ring was calibrated indirectly by means of loads placed on three 100,000-lb-capacity proving rings. These rings were calibrated directly by the 111,000-lb dead-weight machine at NBS—the largest available. By means of a 50-in.-dia hydraulic jack, load was applied to the load cell through the 300,000-lb proving rings in 10 increments of 150,000 lb each up to the maximum load of 1.5 million lb. NBS calibration authorities believe errors in the applied loads do not exceed 0.01%.

Turbine-powered Car to Attempt Speed Record

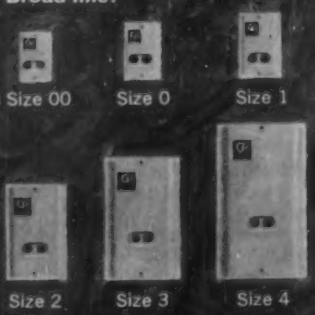

RECIRCULATING BALL STEERING NUT WITH DUAL CHAIN DRIVE
GEARBOX SUSPENSION ARMS
"PROTEUS" GAS TURBINE ENGINE - DELIVERING 4,100 SHP AT 11,000 R.P.M. - MODIFIED TO DRIVE FROM BOTH ENDS
LIFTING JACKS
CAMERA AND LIGHTS
HIGH TENSILE STEEL WELDED HUB
ENGINE FRONT DRIVE WITH FREE WHEEL DEVICE
REAR GEARBOX OIL TANK
BRAKE SYSTEM CHARGING AND JACKING CONTROL PANEL
DRIVER'S INSTRUMENT PANEL
ELECTRICAL SERVICES DISTRIBUTION POINT
BATTERIES
AIR BRAKE ACTUATING LEVER
FIRE EXTINGUISHER CO_2 BOTTLE
REAR DRIVE SHAFT
PHOTOGRAPHIC INSTRUMENT PANEL
AIR BRAKE JACKS
BRAKE SYSTEM AIR STORAGE CYLINDERS
REAR SPIRAL BEVEL GEARBOX RATIO 3·6 TO 1
INTEGRAL LIGHT ALLOY BONDED & RIVETED STRUCTURE
AIR INTAKE ON ENGINE
AIR BRAKE IN EXTENDED POSITION
COCKPIT WITH FORWARD HINGEING PERSPEX CANOPY
ENGINE FRONT MOUNTING
FUEL TANKS - TOTAL CAPACITY 23 GALLONS
FOURWAY EXHAUST DUCT WITH SILICA BATT AND ALUMINIUM FOIL INSULATION
LAMINATED GLASS SAFETY SCREEN
ENGINE OIL TANK
STEERING REDUCTION GEAR BOX
ENGINE REAR MOUNTINGS
FRONT PRESSURE BULKHEAD
REAR TOWING EYE
HONEYCOMB MAIN BEAMS
DISC TYPE STEEL WHEELS WITH DETACHABLE RIMS
CANOPY BALANCE MECHANISM
TWO PEDALS - OPERATING THROTTLE AND DISC BRAKES
FRONT GEARBOX OIL TANK
ELECTRICALLY DRIVEN - FUEL & OIL CIRCULATING PUMPS
INDEPENDENT WISHBONE SUSPENSION ON ALL FOUR WHEELS
REMOVABLE HONEYCOMB PANEL
CONSTANT VELOCITY COUPLINGS
FRONT TOWING EYE
FRONT SPIRAL BEVEL GEARBOX RATIO 3·6 TO 1
REAR PRESSURE BULKHEAD
PNEUMATIC SUSPENSION LEG WITH HYDRAULIC DAMPING
82" DIA x 7·6" TYRES

Designed to reach a peak speed of 500 mph, Donald Campbell's "Bluebird" is the combined effort of 68 British companies. A Bristol-Siddeley "Proteus," free turbine, has been modified to drive all four wheels. The 8000-lb car has a power-to-weight ratio of less than 2 lb/bhp. Engine develops over 4000 bhp. Frame is a $\frac{3}{4}$-in. light alloy foil formed into a honeycomb sandwich. Four longitudinal members and four main cross-members form compartments for driver, engine, transmission, wheels. There are two braking systems—air brakes to slow the car to 400 mph and disk brakes on all four wheels to stop the car from 400 mph in 60 sec.

Smaller! About 20% smaller than Size 0 Starters. Just 5 3/4" wide, 7" high and 4 3/16" deep.

Convertible! Carried in stock with three cover options or easily converted in field from "reset" only to "start and stop-reset" or "three-position selector switch." Kits at optional cost.

Broad line!



CONTROL

A new addition to the famous three star line

New! Save space and money with Cutler-Hammer's Size 00 A-C Magnetic Starter

Takes up to 20% less space... costs 18% less than Size 0 Starters. Now you get two big new bonuses in control selection . . . less space and less money Both with the all new Size 00 Starter.

Before, you had to use a larger starter in applications where it really wasn't needed. But, now you can use the Size 00 in about 40% of the applications where the Size 0 is usually used.

The new Cutler-Hammer Size 00 Starter performs to the same high standards you get from all Cutler-Hammer Starters. And, you still get vertical, dust-free contacts which add so much to more reliable starter performance. Your choice too, of 2-coil or 3-coil overload protection in the same small enclosure.

The Bulletin 9586 Size 00 Starter can be used on any general application. Its maximum horsepower ratings: Three phase: 208/220 volts, 1½ hp. 440/550 volts, 2 hp. Single phase: 115 volts, ⅓ hp. 230 volts, 1 hp. It's available open or in NEMA 1 enclosure. Send for Pub. LO-40-N249.

Why you get more from Cutler-Hammer. New things are happening at Cutler-Hammer—new, better products, new engineering ideas and talent, new plant capacity. We're on the move. And, we'd like to show you how we could help you in any electrical control problem. Contact the nearest Cutler-Hammer distributor.

WHAT'S NEW? ASK...

CUTLER-HAMMER

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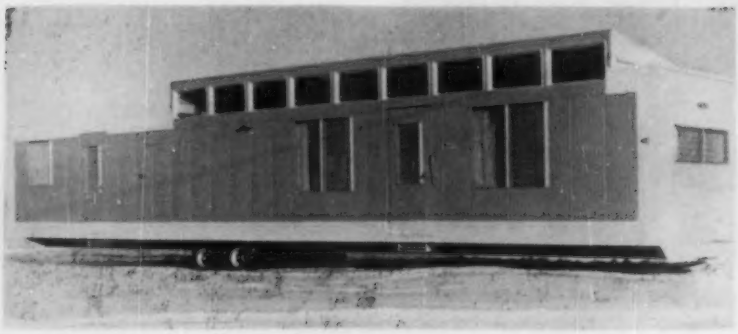
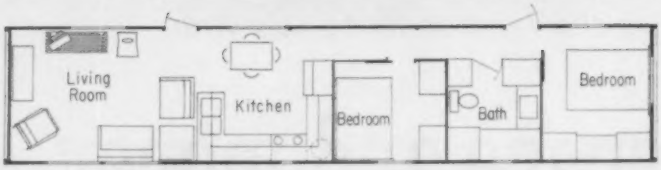
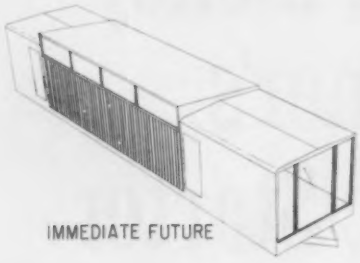
CONTROL

TRENDS IN APPEARANCE DESIGN

ON AND OFF THE

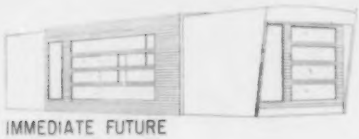






Manufacturers of mobile homes provide many of the latest conveniences found in stationary homes and strive to convey a homelike atmosphere. However, long sweeping lines, similar to automotive styling, are found throughout the industry. Nonfunctional fins have appeared on some models; three- and even four-color combinations have recently been tried; and indiscriminate use of chrome, bright metal, and textured panels have created an amusement-park look.

The effects of this gaudy styling can be seen on the outskirts of practically every city across the nation. Also,



while most conventional residential structures tend to increase in value, the mobile home, like the automobile itself, depreciates with every passing year.

When the engineering and industrial design staff at Battelle Memorial Institute undertook the redesign of the mobile home for New Moon Homes, design themes were conceived for what was termed the "immediate future" and "future" markets.

Future-market models were all based on the modular concept, with vertical door, window, and plain-wall

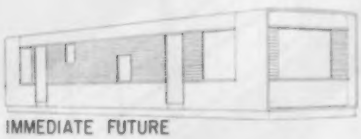
Construction machinery at the recent International Salon of Public Works Equipment, Paris, France, contained an interesting example of how similar design problems tend to inspire similar solutions, even when an ocean separates the manufacturers and their designers. For maximum visibility and accessibility, and to provide surfaces as free of dirt-catching details as possible, the French manufacturer, Berliet, has adopted a slab-like powerplant housing, with a lofty "greenhouse" operator's cab, similar to those found on this type of equipment made in US by Michigan Crane & Conveyor Div and others. Another cab treatment is provided in the Griffet (French) 4-ton crane—after arrival at worksite, driver transfers to adjacent seat, facing in opposite direction, to operate the crane. Radial scraper by Elba Werke (German) provides operator with aircraft-type cockpit, with slide-back canopy. Hydraulic shovel by Nobas (German) proves that you can't make cab and powerplant look like a unit simply by painting some stripes across them.■

BERLIET

MICHIGAN

HIGHWAY

panels of the same width and height. But public acceptance of this future-market group is uncertain at this time and new manufacturing and fabrication techniques have to be developed before the model can be produced. So the design (at far left) chosen for immediate development and production still has the traditional wooden framing. It is characterized by a raised,



IMMEDIATE FUTURE

sloping-roof section with ceiling-level windows that help to (1) break up the boxcar look and slab-like effect of the walls; (2) provide more ventilation and light; (3) increase interior height.

The floor plan was probably the most difficult industrial design problem, partly because the company wanted to continue with the same interior equipment and furnishings. The most troublesome area of the floor plan was the kitchen-livingroom. A ceiling-to-floor physical barrier was ruled out because it reduced the effect of the raised-roof section located over this area. The solution: an island sink, incorporated in a conventional countertop-and-cabinet extending at right angles from the wall. To retain the feeling of spaciousness, the cabinet was raised 4 in. off the floor and the

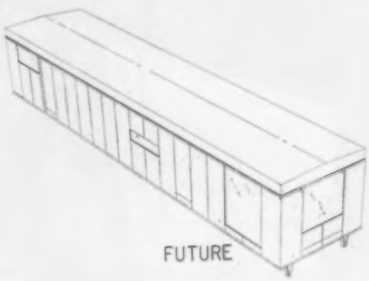
FUTURE

overhead china cabinet given semi-transparent glass doors, front and back.

The 0.030-in.-thick steel panels that sheathe the new model's wood framing are corrugated, in a square pattern about 1 in. wide. This emphasizes the vertical lines, gives depth to the exterior walls, provides integral strengthening and reduces cost of materials.

Over-all costs had to be comparable with those of the old model. This was achieved in spite of the added material of the raised-roof section and the nine additional windows.

The livingroom was made approximately 1 ft. longer even though over-all size of the home was not changed from the original 10 ft. wide, 50 ft long. ■

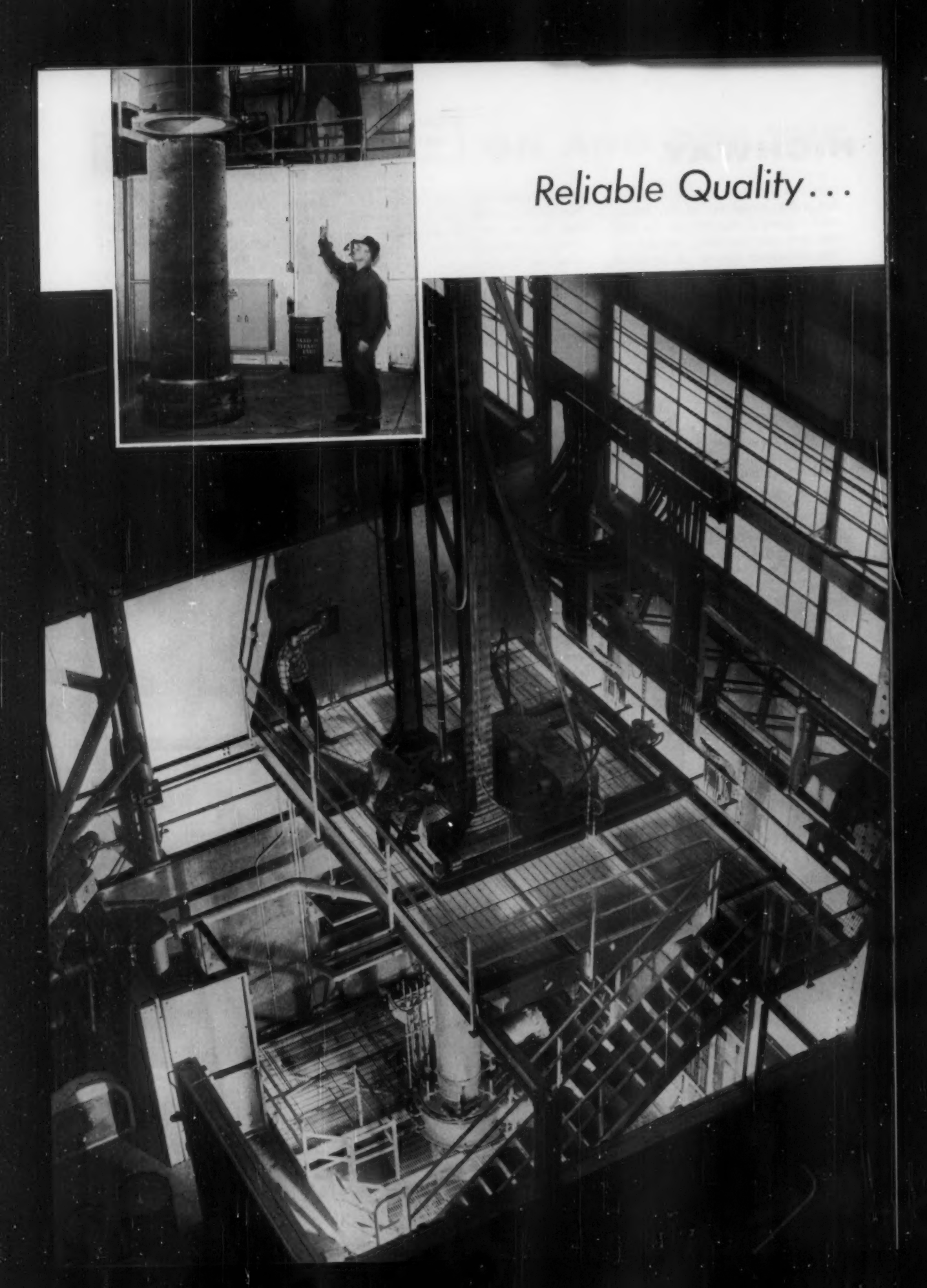


FUTURE

GRIFFET

ELBA-WERKE

NOBAS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For applications where *reliability* is of major importance, Republic offers *vacuum-melted* metals in ingots, billets, sheets, bar, strip, and wire.

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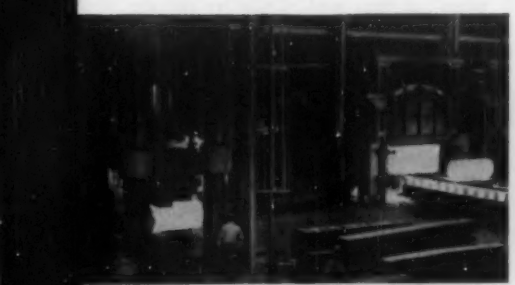
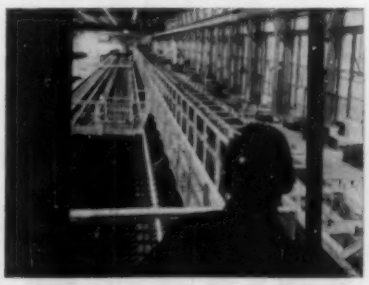
Republic uses the consumable electrode vacuum-melting process. Metals thus produced offer higher mechanical properties—ductility, tensile strength, and fatigue life. Non-metallic inclusions are reduced in number and size. Testing, certification, job setup, and production costs are reduced.

Our metallurgists and engineers are available to help you select, apply, and process the vacuum-melted metal best suited to your requirements. For complete information, contact your nearest Republic sales office today or return the coupon.

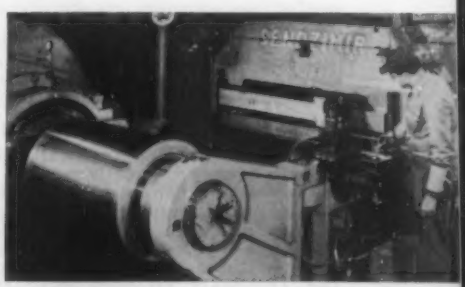
Super Alloy Steels • Constructional Alloy Steels • High Strength Alloy Steels • Bearing Steels • Stainless Steels • Titanium • Special Carbon Steels.



BILLETS—Republic's 3000-ton forging press converts vacuum-melted metals to large billets that are ideal for forged parts manufacture. Segregations associated with dendrite freezing are greatly reduced by the consumable electrode process and further alleviated by the greater hot work reduction ratios permitted by large ingots.



BARS—Vacuum-melted metals are converted into close-tolerance squares, rounds, hexes, and many other shapes on Republic bar mills. Virtually any size can be produced—from ¼″ to 10″ rounds and equivalent footweight sections. These bars offer improved ductility, tensile strength, fatigue life, and resistance to scaling.



SHEETS—Vacuum-melted stainless, titanium, and super alloy steels are converted to light gage sheet and strip on Republic's Sendzimir mills. Large coils up to 48″ (36″ maximum on titanium) wide are produced to close tolerances with excellent finishes and strength-to-weight ratios. Sheets up to 72″ wide can be produced on hand mills.

REPUBLIC STEEL

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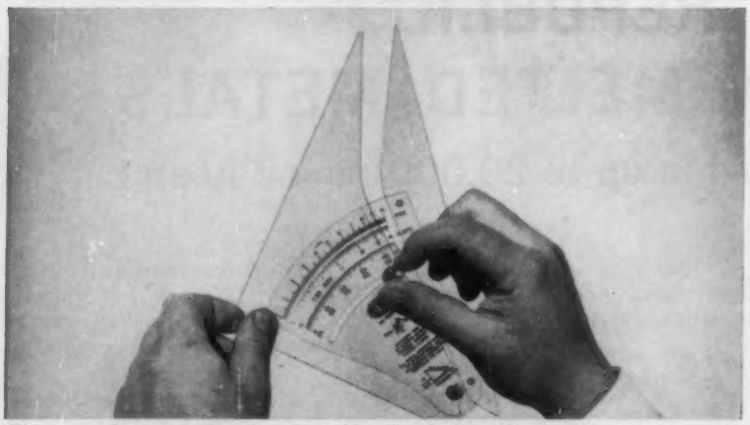
DRAFTING TRENDS



This versatile, easy-to-handle, adjustable triangle is made of yellow-tinted optical-grade acrylic plastic. A clean-cut oval track fitted with metal knurled knob assures ease of operation and lasting tight fit.

New combination protractor-triangle speeds up drafting

Architects, Engineers, Builders, Field Surveyors, Mathematicians—anyone who develops solutions to measurement problems indirectly to determine a wanted measurement graphically or mathematically—will find the Trig-Matk Adjustable Triangle a handy tool. It eliminates much of the graphic work necessary in estimating results or in checking for correct answers.

Versatility with accuracy

Basically, the new POST Trig-Matk Adjustable Triangle is a mathematician's tool—accurate to two decimal places.

It combines the functions of a protractor and a triangle into a simple unit, with two fundamental trigonometric relationships of a right triangle. The Trig-Matk provides accuracy within 1% in problems dealing with any of the six trigonometric ratios of the sides of a right triangle.

The adjustable protractor has three sets of graduations. One set is graduated in half degrees, labeled *Degrees*, and permits the use of the Trig-Matk as a protractor setting for determining any angle from 0 to 90 degrees.

The second set of graduations, labeled *Slope*, shows directly the *Secant* trigonometric ratio of the angle indicated on the degree scale. The third scale, labeled *Rise*, indicates directly the *Tangent* trigonometric ratio shown on the degree scale.

Examples

This new tool has a host of drafting and engineering applications. Highway designers find the Trig-Matk very useful when making cross sections of roadways at ground level or below. By setting the *Slope* scale to the degree desired, road-curve grades are automatically determined. The protractor can be used to determine the angle of highway ingress and egress lanes.

An indicated angle of 40 degrees on the Trig-Matk (1589) shows directly that the Rise is 8.4 to the base of 10.

Structural Engineers will find the Trig-Matk Adjustable Triangle a simple tool, eliminating the use of both a scale and individual triangles. In addition to the time saved, many of the errors usually associated with the older method are avoided. The Trig-Matk design eliminates the need of frequent reference to handbooks for information on various bevels.

Two Bases

The Trig-Matk No. 1589-12 has a 12" base for handy calculations in feet and inches. Number 1589-10 has a base of 10 for decimal calculations.

Keep posted on all the latest trends in drafting. Consult your local POST dealer, or write to Frederick Post Co., 3642 North Avondale Ave., Chicago 18, Ill.

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READER TO EDITOR

Inherent Over-temperature Controls

To the Editor:

Your article on motor protection in the June 13 issue p 51 was very interesting. We agree with your viewpoint 100%. We are using inherent over-temperature controls in the interpole winding of our REACTRON controlled variable-speed dc shunt-type motors (PE—Mar 28 p 80) with excellent results.

Since the quality of the rectified current from our REACTRON control is as good as pure dc under conditions of low motor speed and heavy overload (double full-load current and more), we get very little motor heating. Under these conditions, the over-temperature protector is about the only method of properly protecting our motors and yet allowing maximum torque output. —ARAM KALENIAN
Vee-Arc Corp, Westboro, Mass

Another Word, Please

To the Editor:

I greatly enjoyed your editorial in the May 30th issue, p 41. However I am afraid your word "maintainability" sounds pretty barbarous to me, and since PE has a great influence it might easily come into general use with the equally outlandish word "Winterization." There would seem to be a way out. Instrument engineers use such words as "memory," "sophisticated instrumentation," "several disciplines" in their work. Could we not use the words "hardy" and "hardwood" in regard to pieces of mechanical equipment easy to maintain?

—ALAN OSBOURNE
Cabin John, Md

Change to Metric System

To the Editor:

Regarding the metric system arguments: There are technical virtues and drawbacks to all systems of mensuration but in the current and future situation, technical aspects become so unimportant that they are almost meaningless. There is only one important consideration and that is the economic life of our country. It is obvious that the world is changing over to the metric system—if we do not, we may end up playing solitaire. This is one of the numerous things we must do to help our competitive position in view of the cheap foreign labor market. If the changeover is not started soon it will end up being a crash program with the Federal gov't (the people) footing the bill ten years from now. —A J TRICON
Houston, Texas

Keep Corrosive Elements at Bay

To the Editor:

We were very pleased to see our process of fluoride anodizing given such a prominent place in Dr. Stevens article "How to Specify Finishes for Magnesium" in your issue of June 6th. We wish to

emphasize however, what is not made clear in the article, that it is only a *foundation* treatment and is intended to prepare the way for further protective measures. Its purpose is to ensure an uncontaminated, passive surface, which is an essential step in providing the best possible corrosion-resistant conditions for coating.

Protection of metals is only secured by keeping corrosive elements at bay and this is best achieved in the case of magnesium by giving it a good waterproof coating—paint, resin or porcelain enamel. The full benefit of any coating is only realized if the foundation treatment is right. Mr. Stevens has emphasized the importance of a special pretreatment before porcelain enameling can be carried out successfully, though he is not yet in a position to reveal the details. We believe that this principle applies to all coating procedures and that for both air-dried and high-bake paint systems fluoride anodizing is the best all-round preliminary step. It is equally effective in conditioning a magnesium surface to receive the Dow 17 and the HAE treatments. —W F Higgins
Magnesium Elektron Limited
Manchester, England

COMING EVENTS

AUGUST

1-3 . . . . Institute of Radio Engineers, 4th Global Communications Symposium. Statler-Hilton Hotel, Washington, DC

1-4 . . . . Society of Photographic Instrumentation Engineers, 5th Annual Technical Symposium, Ambassador Hotel, Los Angeles

8-12 . . . . American Institute of Electrical Engineers, Pacific General Meeting, Cortez Hotel, San Diego, Calif

14-17 . . . . American Society of Mechanical Engineers and AIChE, Heat Transfer Conference and Exhibit, Statler Hilton Hotel, Buffalo, NY

23-26 . . . . Western Electronics Conference and Exhibit, Los Angeles Calif

28-Sept 1 . . . . American Society of Mechanical Engineers, International Heat Transfer Conference, University of Colorado, Boulder, Colo

SEPTEMBER

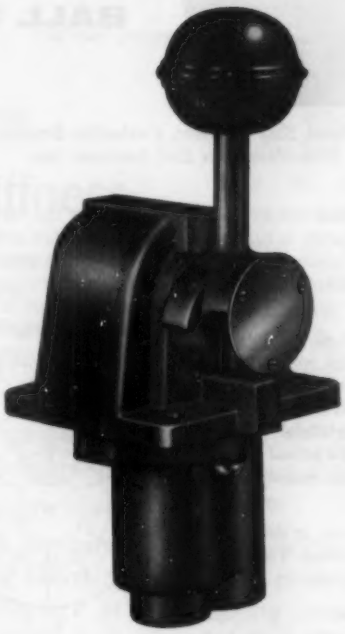
6-16 . . . . National Machine Tool Builders Association, Production Engineering Show, International Amphitheater, Chicago

7-9 . . . . American Society of Mechanical Engineers jointly with AIChE, AIEE, IRE, and ISA; Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Mass

26-28 . . . . Standards Engineers Society, 9th Annual Meeting, Hilton Hotel, Pittsburgh

Another New Westinghouse AIR CIRCUITRY Component

"A" PILOTAIR® VALVES Panel Mounting Type



The famous "A" Pilotair Valves, the deluxe air directional valves, *are now available at economy prices* . . . thanks to new manufacturing processes and simplicity of design.

VERSATILE—By reversing or rotating the all-purpose cam, any "A" Pilotair Valve may be converted from one type of operation to another.

STREAMLINED—Compact and streamlined in design, "A" Pilotair Valves are ideal for deluxe mountings, as in consoles or control panels. Internal parts are totally enclosed.

BETTER QUALITY—"A" Pilotair Valves are essentially all die-cast treated zinc for corrosion resistance. Cams, camshaft and cam followers are made of hardened sintered steel. Seals and seats are made of oil resistant, synthetic rubber to insure close, tight fit and long life.

Several different models are offered in both three-way and four-way operation. Prices range from as little as $18.30 up to $29.50. All operate efficiently at 250 psi maximum air pressure . . . and in a temperature range of from −40 degrees F. to +200 degrees F.

AIR CIRCUITRY . . . FOR TROUBLE-FREE AUTOMATION

Air Circuitry is the application of pneumatic control systems to your production operations.

Air Circuits are safe, economical and precise. They are successfully used to solve the most rigorous and complex control problems in industry.

Our engineers, backed by 90 years of experience, can help you boost production and cut costs in your plant.

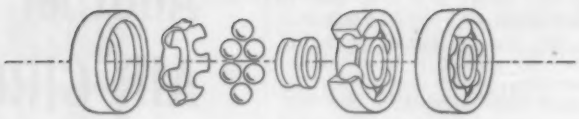
AIR CIRCUITRY means trouble-free automation

For more information, ask for Catalog A4-74.14

See the Yellow Pages under Cylinders for the name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

WESTINGHOUSE AIR BRAKE COMPANY
INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

CIRCLE 29 ON READER SERVICE CARD



MEASURING ROUNDNESS OF INSTRUMENT BALL BEARINGS

By **RICHARD E. AMIDON**, *Staff Engineer, Production Engineering Department*
New Hampshire Ball Bearings, Inc.

Roundness of instrument ball bearings is a variable not covered by ABEC standards. Yet, it is an important factor in running quality. Since it is a very difficult variable to measure, except with costly equipment, most users must accept roundness on faith.

Roundness can be defined as "equidistance of all points on a curved surface from a fixed center". To measure roundness of a ball bearing component, therefore, you must establish its center and radius. However, since its center is not accessible as a point of reference, you must establish an "artificial" center. The closer the assumed or artificial center is to the actual center, the more accurate a given method of roundness measurement will be.

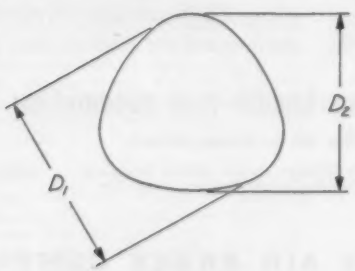
What you're really measuring is out-of-roundness, or deviation from a true circle. Such deviations are called lobing. There are three common ways of measuring out-of-roundness.

THE TWO-POINT METHOD

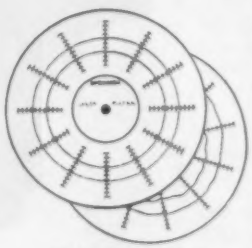
Most widely used of all measuring techniques is the method of measuring various diameters between two anvils as in a micrometer or two-point gage. The difference between the largest and smallest diameter is out-of-roundness. This method is accurate only if there is an even number of lobes of equal height and symmetrical spacing. Notice in the accompanying sketch of a three-lobed shape, all three diameters are equal . . . and the two-point method would indicate perfect roundness.

THE THREE-POINT METHOD

When an odd number of lobes exists, a three-point gage can be used to measure out-of-roundness. Variations are measured by rotating the part between two fixed points at a known angle with each other and a movable point connected to an indicator. This method, which calls for calculations to convert indicator readings to true-out-of-roundness, is accurate only when the number of lobes is known and they are symmetrically spaced and equal in height.



ELECTRONIC GAGING



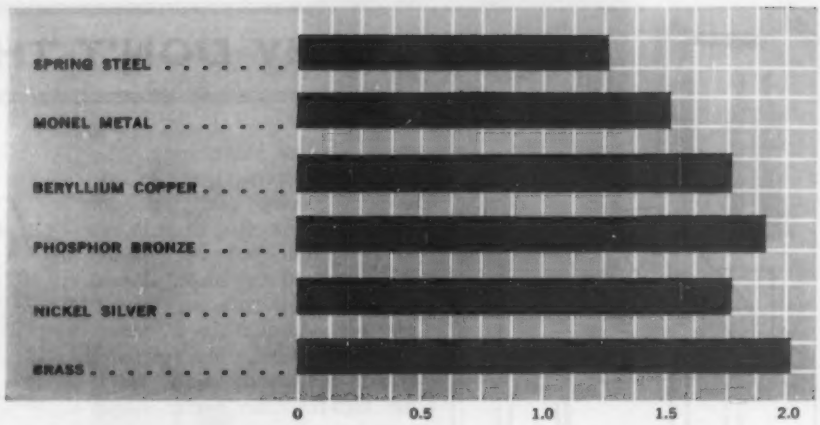
POLAR CHART TRACE

Fortunately for you, instrumentation has been recently developed which measures out-of-roundness directly as radial variation with accuracy to several millionths of an inch. The part to be measured is chuck-mounted to a precision spindle and slowly rotated. An electronic gage head translates radial surface variations into a polar chart trace with deviations magnified as much as 10,000 times. Comparison of the chart trace with concentric circles of known radii reveals absolute deviation from a true circle. New Hampshire Ball Bearings, Inc. was the first to use this instrument as a quality control tool in the laboratory and on the production line. Other instrumentation used to assure the running quality of New Hampshire Bearings is described in our new Design and Purchasing Manual.

NEW DESIGN MANUAL

Newly revised and expanded, this authoritative publication covers everything you need to know about applying and buying miniature and instrument ball bearings. Comprehensive general information, catalog data and engineering bulletins are included in its 100-plus pages. Personally registered copies are available to qualified engineers, draftsmen and purchasing agents. Please send your request on your company letterhead.

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.



PER CENT DECREASE IN STIFFNESS WITH 100°F. INCREASE IN TEMPERATURE

How Temperature affects spring stiffness

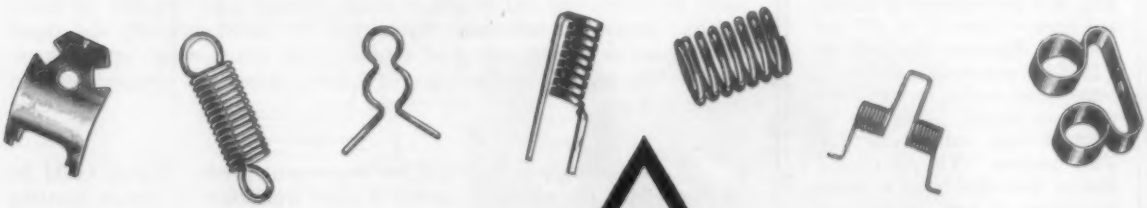
When service or operating temperatures are above room temperature, spring selection must take into consideration several factors usually of little consequence in ordinary service.

These are loss of strength, thermal expansion, deflection, drift and hysteresis.

The first effect — loss of strength — is usually the most serious. What happens is that the safe stress carrying capacity of the spring material decreases at higher service temperatures and springs of ample strength at room temperature may be too highly stressed when heated.

These effects may be small in many cases, but under some conditions they may be important, particularly when temperatures vary over a wide range. Where an accurately determined spring strength at elevated temperature is desired, the specifications covering load test at room temperature should be corrected for the change that will occur. The approximate amount of correction for 100° F change in temperature for various materials is shown in the chart above.

With today's increasing high-temperature problems in many fields, proper spring selection is more than ever important. The subject is discussed in our latest pamphlet, "High Temperature Springs." Write for your copy.



Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
F. N. Manross and Sons Division, Bristol, Conn.
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.
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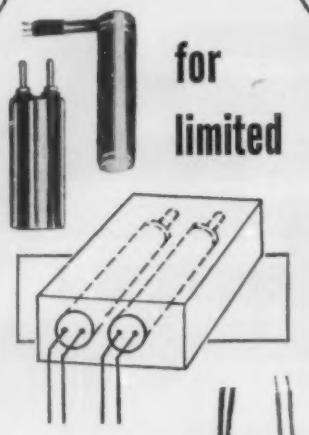
Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.



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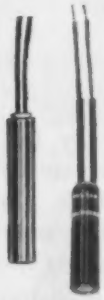


VULCAN
CARTRIDGE HEATERS

Vulcan Cartridge Heaters are designed especially to provide concentrated heat in small areas by insertion into machine parts, dies, platens, molds, presses, die blocks of embossing machines, packaging machines, etc. There is practically no heat loss because the cartridge is completely surrounded by the metal or material to be heated.

Vulcan Cartridges are available in a wide choice of standard sizes — from 1″ to 25″ (or longer); diameter — 1/4″ to 1 19/64″ (or greater); sheath — brass, steel, nickel or high temperature alloys; full range of wattage and voltage ratings. The proven "Thunderbolt" Heater is available for extreme conditions of watt density and temperature.

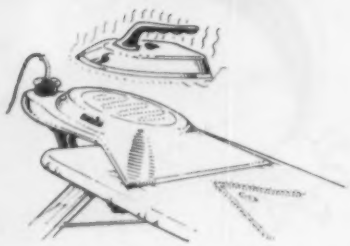
Write for catalog and prices.

VULCAN

Versatility in Electric Heating

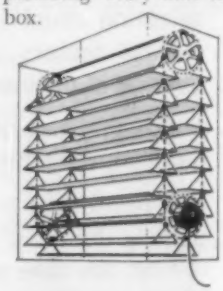
VULCAN ELECTRIC COMPANY, Danvers, Mass.

WHY DON'T THEY R&D..?



. . . a cordless electric iron. The cord on an electric iron is a nuisance, becomes easily tangled, makes ironing more difficult, hangs where the iron can be easily pulled or knocked off the board. Instead of the present resistance element, why not heat the iron by induction heating from a high-frequency field in the ironing board? Or, if the high-frequency power supply were too expensive, a more practical device might be built with a resistance element and a 60-cycle induction coil in the board. The coil in the board would induce a current in a pickup coil in the iron and this current would heat the resistance element. Perhaps the induction unit could be simply an attachment to the board (as shown in the sketch) rather than a coil wound over the entire surface of the board. **–L van Zeyl**

. . . something new in the way of kitchen accessories. How about a bread box which is evacuated each time the box is closed? This would keep air and moisture from making the bread stale or moldy. The air might be drawn off by a simple venturi pump attached to the kitchen plumbing–every time the faucet was turned on, it would evacuate the storage box.



Or why not put shelves for kitchen cabinets on a motorized endless chain, ferris-wheel fashion, so that a flick of a switch would bring any desired shelf within easy reach. Though shelves would be less than half as deep as those in present cabinets, the contents of the shelves at the back of the cabinet could be brought to the front by simply rotating the conveyor. With relatively inexpensive motors now available, and with the general trend toward electrical kitchens, this unit should be well within the range of practicality.

A toaster with a magazine feed for large families would simplify the problem of tending the ordinary two-slices-at-a-time toaster. The magazine would be loaded with bread and as each pair of slices is done, they would be shifted to a storage chamber heated just enough to keep them warm.

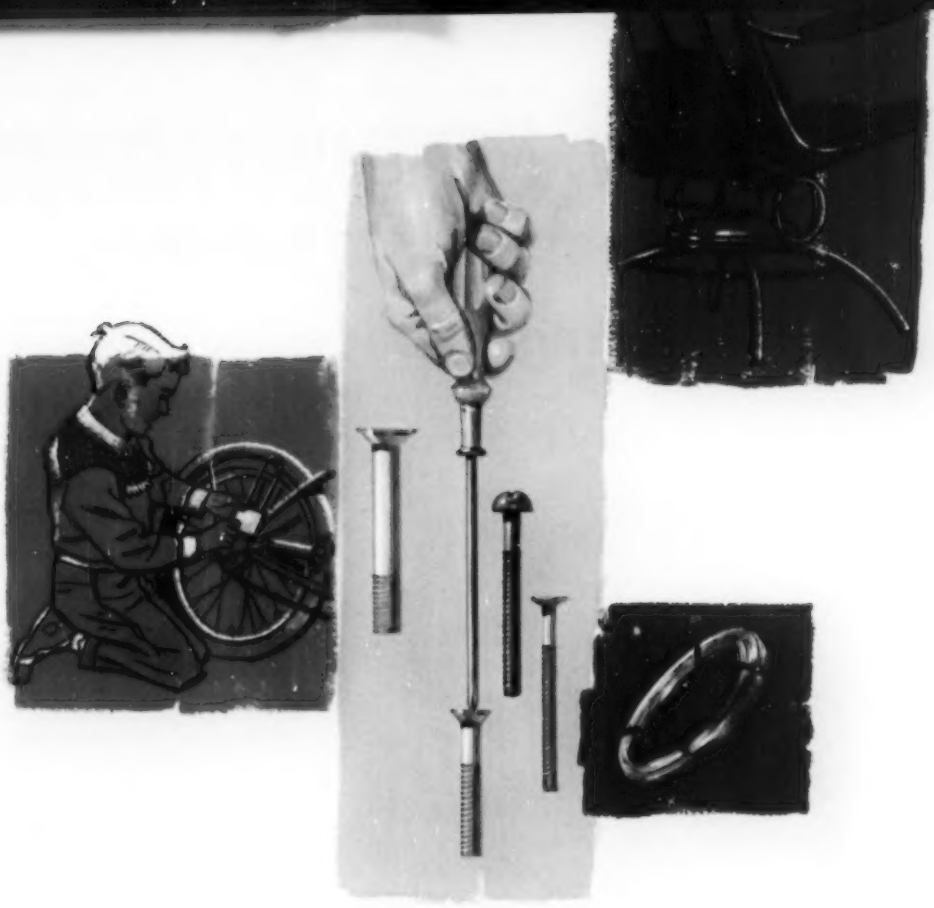
Two other accessories might also find a market. (1) A refrigerator attachment for dispensing soft drinks to reduce storage space required by bulky bottles. Syrup and carbonated water could be stored externally and piped to dispenser as needed. (2) And a defroster for frozen meats, operating on the principle of dielectric heating, would reduce delays now required between freezer and oven. **–R Marie**

. . . a package-wrapping machine for department stores. Parcels could be gift-wrapped in the customer's choice of paper and ribbon by simply inserting the article to be wrapped (through an opening that limits the machine to boxes one cubic foot or less, for example) and setting a selector. Cost of the service would depend on the amount of wrapping materials used. After wrapping, and while the package is still in the machine, an indicator would show the charges (between 10¢ and 50¢). The customer would then insert the proper coin to retrieve his package. **–E E Reed**

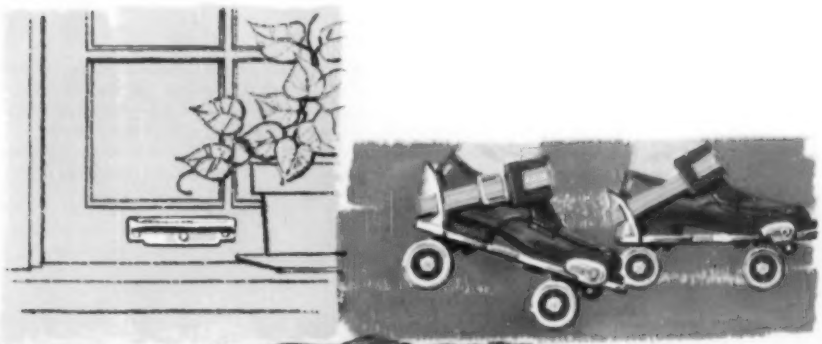
Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.

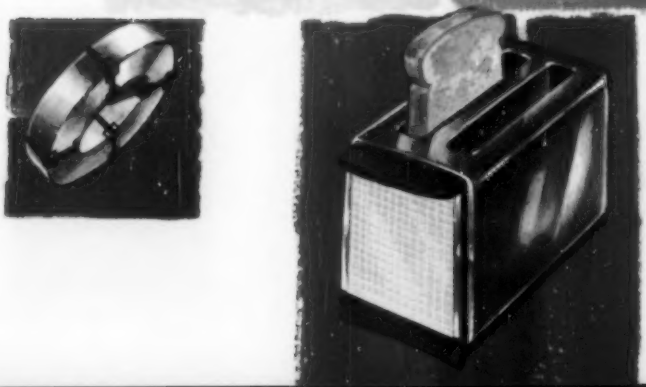
CIRCLE 32 ON READER SERVICE CARD

CIRCLE 33 ON READER SERVICE CARD→



Quality products call for quality wire, bars and strip . . .



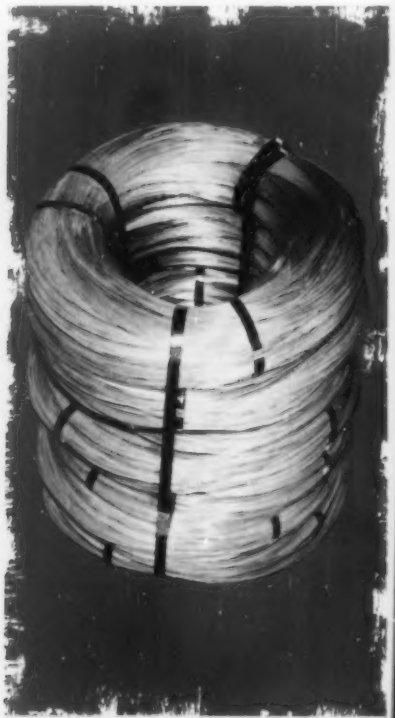


American Steel & Wire
Division of
United States Steel

USS American Quality Manufacturers Products packaged to speed up handling and save storage space

Standard Coils: American Steel & Wire manufactures standard coils in weights suited to your material handling equipment.

Heavyweight Coils: These continuous wire coils, weighing up to 2,000 pounds, speed up your production by reducing down time for setups and changes. One large coil takes the place of several smaller coils of same total weight—are much easier to handle . . . require much less storage space.



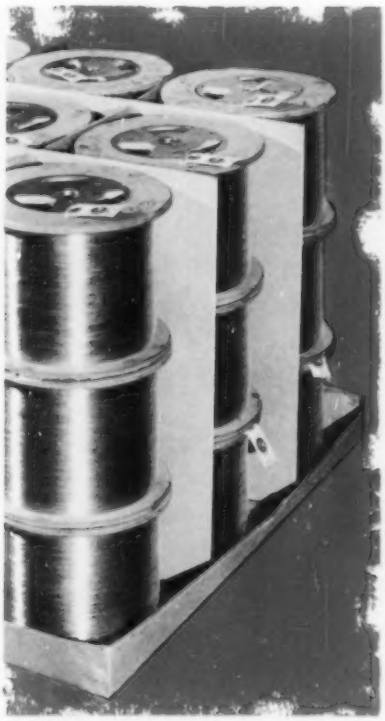
Unitized Coils: These unit packs offer great savings in handling time and storage space. One unit, containing several coils, is easily handled; takes up less storage space than the same coils stored separately.

. . . quality controlled to help you make good products better

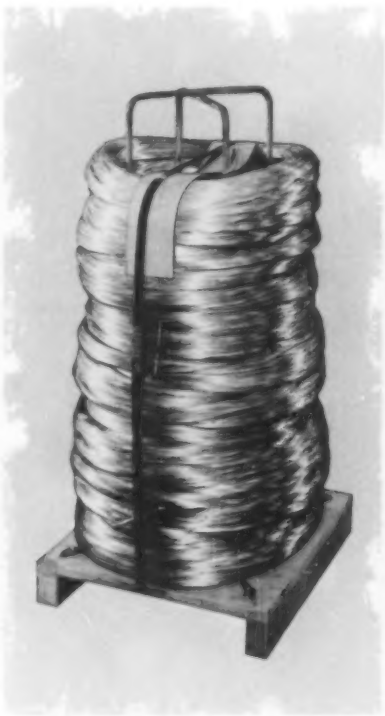
To mass produce this bicycle padlock the Master Lock Company uses USS Amer-Led Steel Bars. This leaded steel permits increased machining speed over equivalent non-leaded grades. The use of USS Amer-Led results in more accurate forming; . . . fewer rejects.

American Steel & Wire products and service facilities are available to you at no increase in cost. It will pay you to use these advantages. The quality and uniformity of USS American Manufacturers Wire brings you production economies through easier processing and fewer rejects. It makes a superior finished product that is more salable. And it is available in all the modern money-saving forms:

Pay-off Drums: Long-run continuous coils of wire are packed and delivered in heavy fibre containers. These Pay-off Drums are easy to handle and stack for storage. These are ideal for use where wire finish requires special protection from dirt and corrosive atmospheres. Available in most wire sizes with length and weight of coil to your specifications. You do not need to return drums.

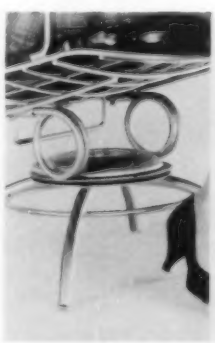


Disposable Spools: These new non-returnable spools can be supplied with any amount of fine wire—from 5 lbs. to 100 lbs. These are easy to handle individually, and when shipped in quantity are delivered 36 to a pallet, ready for storage.



Platform Coil Carrier: The disposable platform carrier, made up of a U-shaped wire frame fastened to a platform, holds up to 3,000 pounds of special wire in one continuous length. It is often ideal for ordering and handling quantities of wire.

American Screw Company turns out 14 million recessed head fasteners a day. Their most famous patent is the Phillips Head Screw, for which American Steel & Wire developed a special cold heading wire, hard enough to produce strong, tough fasteners, yet soft enough to avoid splits and cracks when the Phillips punch is rammed into the coning blank.



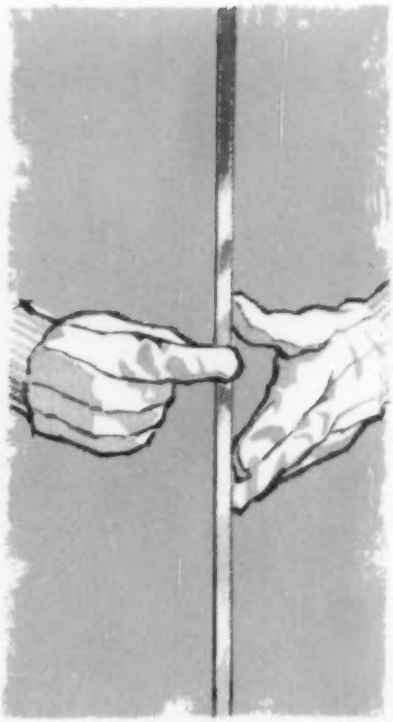
The pair of round wire helical single coil torsion springs on this chair were specially made for the Homecrest Company of Wadena, Minnesota. Under a 250-pound weight, the chair was test rocked 750,000 times without showing any sign of failure. *Another success story for USS American Manufacturers Products.*

American Steel & Wire
Division of
United States Steel

USS

USS Amerstrip . . . gives you precisely what you need in a cold rolled strip

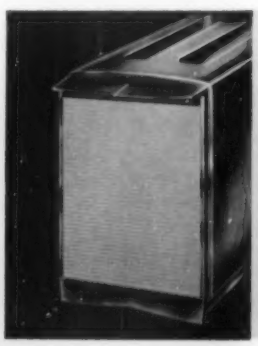
Precision Finish. With USS Amerstrip we take special pains to give you a finish that is just right for the specific results you require in a finished product. We believe the Amerstrip finish is the finest you can get in the industry.



Precisely Prepared Edges. Because USS Amerstrip is produced in order-sized quantities engineered to your own specifications, we can give you exactly the edge finish you need—square, standard, round, full round or bevel.

Precise Tempers. Whether your product must go through a deep draw or undergo other stringent forming operations, or if it requires a special temper for rigidity, you'll get the correct temper for the job when you order USS Amerstrip.

. . . to speed up production and keep your product quality high!



Much of the sales-pulling beauty of Proctor Electric Company's modern toaster is due to the use of gold-finished, geometric-patterned USS Embossed Amerstrip. American Steel & Wire specializes in the rolling of special embossed designs such as this for specific applications. Perhaps you, too, have a product which could be made more beautiful and more sales appealing with Embossed Amerstrip.

USS Amerstrip is a specialty product that has opened vast new production and sales possibilities for a growing number of alert manufacturers of consumer products. It is available in a variety of attractive finishes—plain or embossed. It permits production on precision machines. When you use USS Amerstrip, you get six distinct advantages not easily obtainable with other manufacturing methods or materials:

Precise Width Tolerances. When your fabricating machines require a special width strip, you can be sure that's the width you'll get. We can produce USS Amerstrip within required tolerance limits to fit your special requirements.

Precise Thickness Tolerances. Whatever the thickness tolerance your machines demand, USS Amerstrip can give it to you. We can roll Amerstrip down to thickness tolerances of plus or minus .0005 inches.

Precise Uniformity. Regardless of the size of your order every coil of USS Amerstrip comes off the line uniform in finish, temper, width and thickness. In short, USS Amerstrip's precision production assures a continuous run and high yield.

Amerstrip is used in the manufacture of almost every part of the 15 types of Hustler Corporation skates made by Frantz Manufacturing Co. These skates will stand up under the punishing wear children may give them—yet maintain their attractive finish. Amerstrip is tailored to each particular job . . . has the physical properties to assure a good performance and efficient manufacture.

Amerock Corporation of Rockford, Illinois, makers of sash lifts, had trouble finding a strip steel that would meet its severe double drawing operation requirements. They brought the problem to American Steel & Wire. Our metallurgists recommended a type of USS Amerstrip tailored to their deep drawing requirements and capable of holding a finish suitable for plating.

American Steel & Wire Division of United States Steel

USS

Facilities and service second to none!

As the country's largest manufacturer of wire and strip, we offer a *single source of supply* for all your varied manufacturers' wire and strip requirements.

Widespread *modern facilities* assure that your product will be made exactly to specification, thoroughly uniform in quality and dimension.

Experienced sales representatives are at your service to assist in determining how USS American Manufacturers Products can help make *your* product better.

For more detailed information, get in touch with the nearest district office. American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.

USS, American and Amerstrip are registered trademarks

American Steel & Wire
Division of
United States Steel

This mark tells you a product is made of modern, dependable Steel.

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Phoenix: Arrow Valve Corp. AL 4-7294
CALIFORNIA
Inglewood: Aero Bolt & Screw Co. OR 8-3931
Oakland: Nor-Cal Supply Co. LO 9-3121
Glendale: Robert B. Porter Co. CH 5-7631
Hayward: Robert B. Porter Co. JE 7-0300
COLORADO
Englewood: Rocket Components Co. 9-2548
FLORIDA
Jacksonville: Dixie Bearings, Inc. EL 5-1387
Miami Springs: Wencor, Inc. NE 5-0700
GEORGIA
Hapeville: Air Associates, Inc. PO 6-5353
Atlanta: Dixie Bearings, Inc. JA 4-5601
ILLINOIS
Chicago 10: Jay Berwanger Co., Inc. DE 7-5373
Chicago 22: W. H. Salisbury Co. HA 1-4850
Northbrook: Syntech Rubber Corp. CR 2-2210
INDIANA
Indianapolis: Avels Sales & Eng. Co. ME 9-1326
IOWA
Cedar Rapids: Globe Mach. & Supply EM 5-6911
Davenport: Globe Mach. & Supply 2-7151
Des Moines: Globe Mach. & Supply CH 4-3231
Spencer: Globe Mach. & Supply 1786
KANSAS
Kansas City: Standard Products, Inc. DR 1-2266
Wichita: Standard Products, Inc. AM 2-5161
KENTUCKY
Louisville: Dixie Bearings, Inc JU 3-2775
Louisville: General Rubber & Supply ME 5-2606
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New Orleans: Dixie Bearings, Inc. MA 6363
MARYLAND
Baltimore: Louis H. Hein Co. MU 5-5654
MASSACHUSETTS
Boston 10: Irving B. Moore Corp. HU 2-7565
MICHIGAN
Kalamazoo: Depatie Fluid Power FI 4-1830
Detroit 1: J. N. Fauver Co. TE 2-4115
Flint: J. N. Fauver Co. PI 2-3300
Detroit 39: Roger Zatkoff Co., Inc. KE 2-2121
MISSOURI
St. Louis 8: Foster Mech. Equip. JE 3-9610
Joplin: Industrial Equip. Co. MA 4-1400
St. Louis 3: Sealtite Corp. CE 1-7724
NEBRASKA
Omaha: Wilson-Wylie Dist. Co. AT 9873
NEW JERSEY
Hasbrouck Hts.: C. E. Conover & Co. AT 8-3800
Jersey City: Louis H. Hein Co. HE 5-1965
NEW YORK
Woodside: Durham Aircraft Services AS 4-9000
Alden: Hercules Packing Corp. MU 2300
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Waverly: Staver Hydraulic Co. TU 2-2751
NORTH CAROLINA
Charlotte: Dixie Bearings, Inc. ED 2-2151
Greensboro: Dixie Bearings, Inc. BR 4-4686
OHIO
Cleveland: Cleveland Ball Bearing Co. HE 1-8866
Cincinnati 13: J. N. Fauver Co. TW 1-8400
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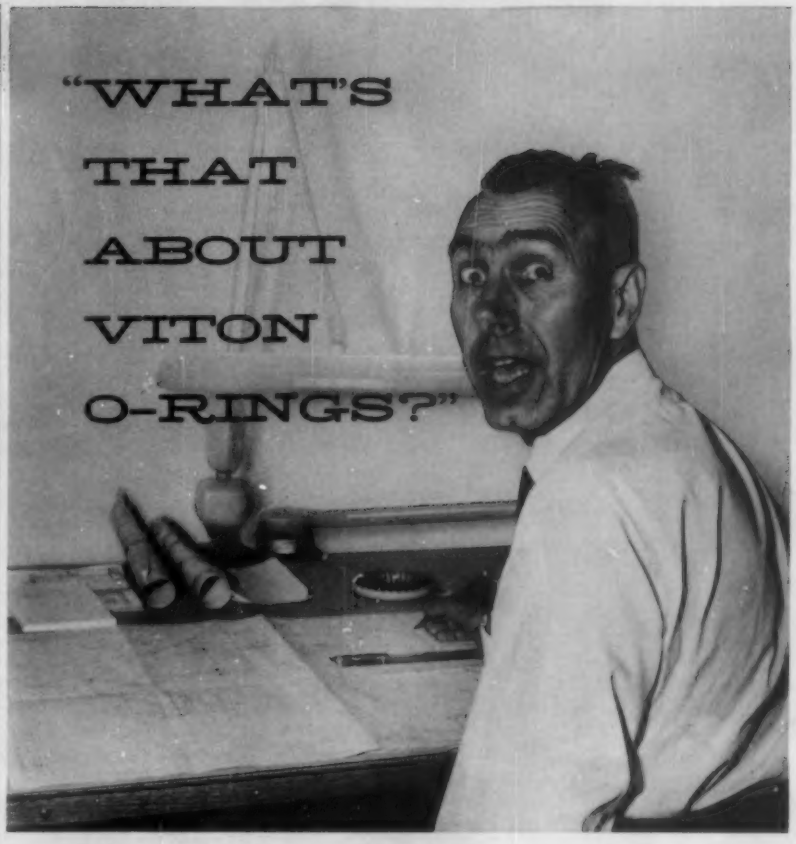
Columbus: Williams & Co. AX 4-1623
OKLAHOMA
Oklahoma City: Ind. Gskt. & Pack. Co. CE 6-4321
Tulsa: Ind. Gskt. & Pack. Co. LU 7-2365
Tulsa: Standard Products, Inc. TE 8-3371
OREGON
Eugene: Bearing Sales & Service DI 5-0325
Portland: Bearing Sales & Service CA 6-7141
Roseburg: Bearing Sales & Service OR 3-4641
PENNSYLVANIA
Philadelphia 40: Goodyear Supply Co. DA 4-5361
Pittsburgh 19: Industrial Rubber Prod. AT 1-0455
W. Conshohocken: Louis H. Hein Co. TA 8-5500
Corry: The Al Xander Co. 2-5551
SOUTH CAROLINA
Greenville: Dixie Bearings, Inc. 5-9601
TENNESSEE
Chattanooga: Dixie Bearings, Inc. AM 7-9526
Knoxville: Dixie Bearings, Inc. 5-4137
Kingsport: Dixie Bearings, Inc. CI 6-6195
Nashville: Dixie Bearings, Inc. CH 2-7351
Knoxville: Leinart Engineering Co. 5-0363
TEXAS
Dallas 35: Milam Aircraft Supply Co. FL 1-3766
Houston 1: Sterling Pack. & Gskt. Co. CA 8-4404
Odessa: Carpenter Bearing Co. FE 7-8635
UTAH
Salt Lake City: Alta Engineering Co. EM 4-5587
VIRGINIA
Norfolk: Dixie Bearings, Inc. MA 5-0506
Richmond 22: Dixie Bearings, Inc. MI 4-7837
Alexandria: Specialties, Inc. KI 8-4935
WASHINGTON
Aberdeen: Bearing Sales & Serv. Inc. LE 2-8933
Everett: Bearing Sales & Serv. Inc. AL 9-1185
Longview: Bearing Sales & Serv. Inc. HA 5-1850
Pasco: Bearing Sales & Serv. Inc. LI 7-2421
Port Angeles: Bearing Sales & Serv. Inc. GL 2-2307
Seattle: Bearing Sales & Serv. MU 2-0331
Tacoma: Bearing Sales & Serv. FU 3-5363
WISCONSIN
Milwaukee 4: Allrubber Prod. & Sply. Co. BR 3-4900
Milwaukee 6: Great Lakes Rubber & Sply. FR 4-4300
CANADA
Montreal: Railway & Power Eng. WE 3-6741
Toronto 2: Railway & Power Eng. EM 2-4771
Hamilton: Railway & Power Eng. JA 8-4251
Windsor: Railway & Power Eng. CL 6-5408
N.D.G. Montreal, E.: Abercorn Aero Ltd. HU 9-4978



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"Parker Seal Company has pioneered in research, developing and engineering Viton O-Rings. This responsible leadership in O-Ring engineering enables them to offer these firsts in Viton:

1. All AN (ARP) sizes as *standards* — no charge for tooling, faster delivery, *proved* and *tested* quality.
2. Industrial Viton O-Rings at amazingly low cost.
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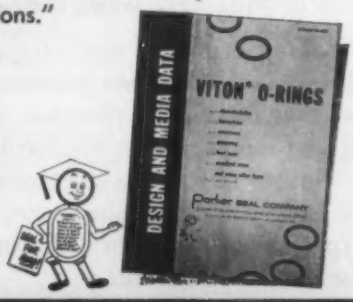
4. Little or no lead time, even on "exotic" compounds developed for special applications."

Parker Seal Company's nation-wide staff of sales engineers and distributors are eager to serve you. If you would like a copy of our Viton O-Ring Handbook call the distributor nearest you (see list at left) or write direct to factory.



Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio
A DIVISION OF PARKER-HANNIFIN CORPORATION

CIRCLE 39 ON READER SERVICE CARD 39

Our on-the-job services make your job easier

You can save considerable time and money in getting flexible connectors best suited to your needs by utilizing the sales engineer consulting services of Anaconda Metal Hose Division.

We are specialists in designing and producing flexible connectors to meet problems of expansion, contraction, movement, vibration, corrosion, pressures, and temperatures. We have broad experience working in stainless steel, other steel alloys, Monel, copper alloys, aluminum, and Teflon*. Our specially trained men will come to you. This is how our services work:

You let us know your flexible connector needs—with conditions, dimensions, and such sketches or drawings as might be necessary for us to understand the problems.

We will work out design problems with your engineers and draftsmen.

We will make specialists available for immediate service calls on equipment or field installations.

We will follow through from original design to finished product.

Our specialists are available to you through Anaconda Metal Hose representatives in leading cities – see listing "Hose-Metal" in the Yellow Pages. Or write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

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ANACONDA®
METAL HOSE

CIRCLE 40 ON READER SERVICE CARD

PRODUCT ENGINEERING HORIZONS

July 25, 1960

"Vass you dere, Sharley?"

We have spoken periodically of "the most efficient servomechanism ever designed—weight 160 lb, life 65 years." This of course is man, who is usually around to correct minor malfunctionings or interpret confusing data. He makes more mistakes than automatic mechanisms do, but he is, paradoxically, also more reliable in that he can originate a course of action that a machine cannot.

This is the real reason behind the necessity for putting a man into space. All the instruments and controls we can originate are in effect designed with one foot on the ground—they cannot measure or control something we earthbound humans did not expect.

It is easy to lose sight of this principle in any design, to go ahead on the basis of knowledge and experience—and thus to be wrong. So very many of the things we've learned from experience just aren't so.

Mark Twain talked about it once in discussing the cat who sat on a hot stove lid, and thereafter wouldn't sit on any stove, hot or cold. The cat confused the object with the condition, and there wasn't enough brainpower there to analyze the problem and arrive at a distinction.

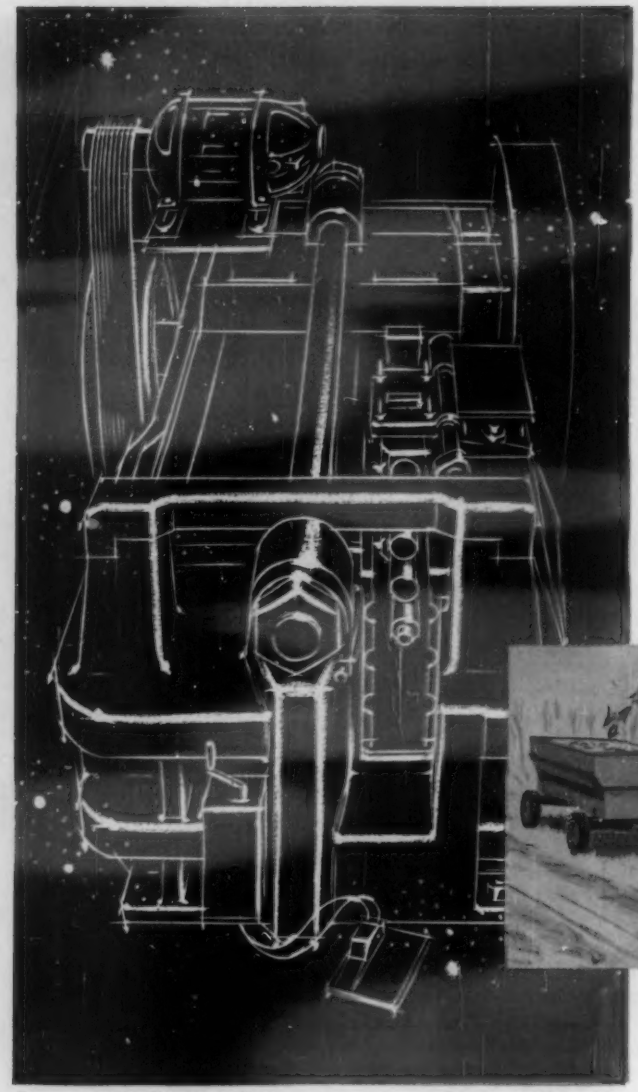
This is often the major flaw in the ability of the second-guesser. He's not confused by the facts of the case. Remember the paraphase of Kipling: "If you can keep your head when all around you are losing theirs—you just don't understand the situation."

There's a good deal of the Monday-morning quarterback, armchair admiral or sidewalk superintendent in most of us. We can sit back and do better in running government, industry or education than the people who have the responsibility. "If I were king . . ." is a wonderful dream, but a nightmarish reality. The facts make the difference.

Consider such a familiar occurrence as a meeting or a conference. It's easy to send someone to get the information you know will be presented. But you can't send him to ask the questions that you can't anticipate, the questions you'd have asked based on an inflection or a look or an unguarded answer to a stock question. To ask those questions, and to get the answers, the man who knows must be there in person.

Somehow, the basic problem seems to be reflected in the frequent question of the radio Baron Munchhausen: "Vass you dere, Sharley?" If Charley wasn't, he doesn't really know. And the only way to find out is to go there; then he's talking from knowledge.

F. Stevenman



Upsetter, or horizontal forging machine

RESISTANCE TO PUNISHMENT of any severe-service part increased by designing it to be forged

Gear blanks for tractor and farm implement transmissions are designed to be upset-forged, usually with integral forged stub shafts. Forging gives these vital parts maximum resistance to gear-clashing shifts. Transmission life can be equal to equipment life when gears are FORGED.

When you *design with forgings* right from the start, you take full advantage of the many benefits which only forgings offer: highest ratio of strength to weight . . . highest resistance to impact, shock, vibration, torsion . . . preferential orientation of flow lines in the forging to concentrate strength where required . . . absence of wasteful inclusions and voids.

Forged parts start out as *better* metal . . . are made *even better* by the hammer blows or pressures of the forging process. Write for literature to help you design, specify, and procure forged parts.

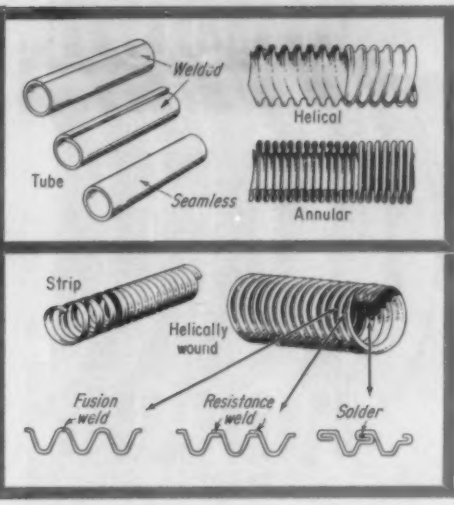
When it's a vital part, design it to be FORGED

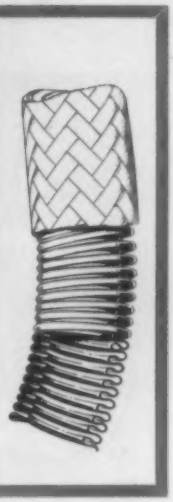
Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine

CORRUGATED HOSE CONSTRUCTION

Corrugated hose is made from tubing (top sequence) or profiled strip (bottom sequence). A braided cover is usually added. Tubing, either welded or seamless, is corrugated to give flexibility. Profiled strip is wound helically, then welded, brazed or soldered to make absolutely leakproof. (Interlocked hose not to be confused with corrugated hose—has sliding joints.)





HOW TO AVOID METAL-HOSE FAILURE

Metal hose in high-pressure, high-temperature, flexing applications can last a hundred years—or fail in minutes. It all depends on how you apply it. Here, for the first time, the author details all known causes of failure, and tells how to overcome them.

WHY METAL HOSE

Metal hose is particularly suited to solving many problems that synthetic hose cannot handle. Here are some of its characteristics:

- Offers resistance to deterioration from age, heat, oils, fuels, chemicals, steam, hot water.
- Tolerates abnormal temperatures from —460 F to 2000 F.
- Is completely fireproof.
- Impervious to searching gases and fluids.
- Can withstand extreme pressures (to 30,000 psi).
- Available in large diameters (to 24 in.).
- Flexible in large sizes.
- Can withstand low vacuum collapse in all sizes.
- Allows visual examination of hose condition.

L B DONKLE, *chief development engineer*
Flexonics Corporation, Maywood, Ill
(Subsidiary, Calumet and Hecla Inc)

When you need flexible piping for applications where temperatures and pressures will be high and leakage must be zero, corrugated metal hose is one answer. But when designing with it you must first consider some of its conflicting characteristics. For extremely high pressures, thick-wall hose is required; yet for maximum flexibility and fatigue life, thin-wall hose is superior. What's more, metal hose often is exposed to corrosive fluids (or atmospheres) where a thick wall is essential, forcing a sacrifice in flexibility.

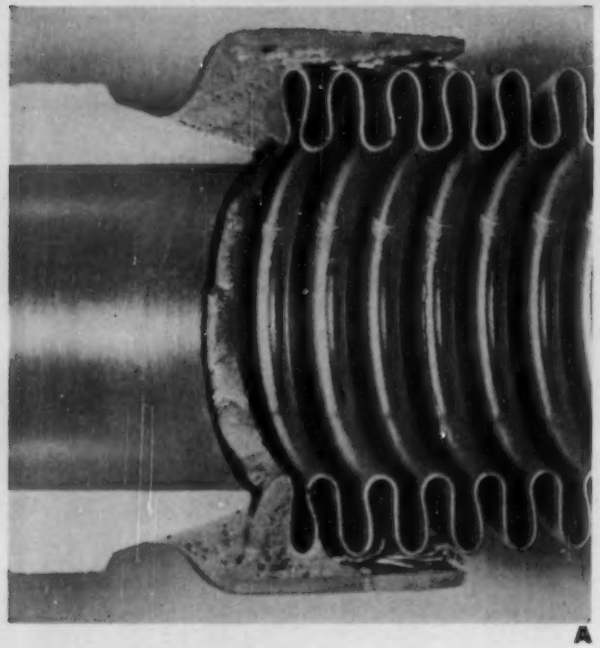
Before choosing the exact type, it is helpful to consider the reasons for hose failure.

Extensive in-the-field analysis in conjunction with metallurgical laboratory examinations have pinpointed these five main causes.

1. **Fatigue**
2. **Corrosion**
3. **Temperature**
4. **Internal pressure**
5. **External abuse**

Usually a hose installation involves a combination of adverse conditions, so it is difficult to predict the type of

continued, next page



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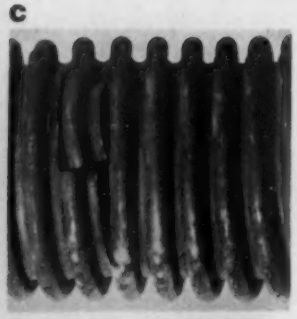

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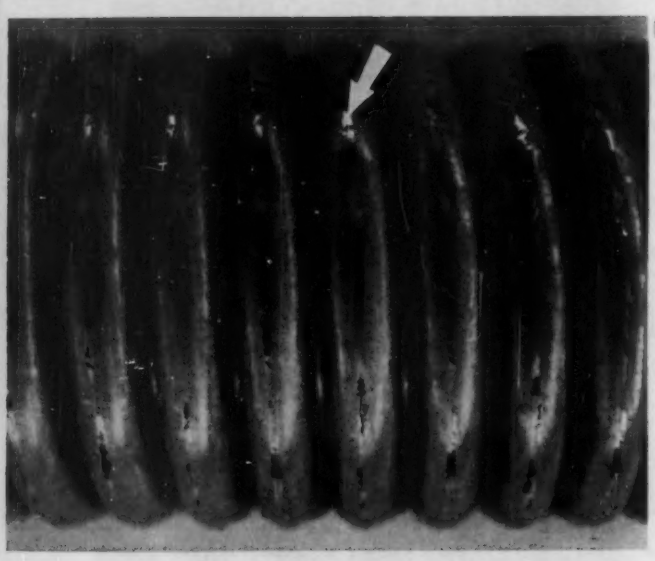

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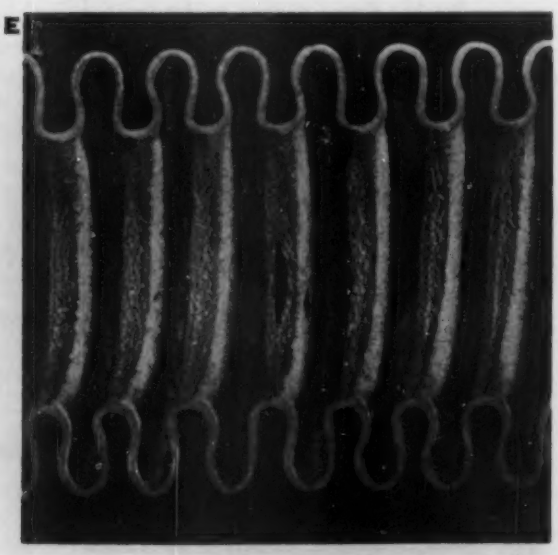


E

FIVE TYPES OF HOSE FAILURE

Corrugated hose types (A), (B), (C), and (D) show fatigue failures; type (E) shows cavitation-erosion. (A) Simple flexure fatigue. Note fairly straight circumferential crack. (B) Vibration fatigue. Cracks are irregular, and pieces occasionally break from wall (sample is from expansion joint). (C) Torsion fatigue. Starts as simple crack, but may curve into sidewall, over corrugation crest. (D) Pressure-cycling fatigue. Crack (under arrow) is similar to that for simple flexure, except abrasion marks on crests (from braid) are often more noticeable. (E) Cavitation-erosion. Flow of fluid has worn corrugation valley completely away.

failure, if any, that will occur in a given application, unless a prototype hose is tested to destruction under closely simulated service conditions. Therefore, it is highly recommended that you consult a hose manufacturer; he may have data on similar applications and be able to recommend the right hose design. To help guide you to the right design choices, here is a detailed analysis of known causes of failure in corrugated metal hose, and advice on how to avoid them.

FATIGUE

Simple flexure fatigue results from low-frequency, high-amplitude motion found in many industrial applications. Examples: connectors for pumps, compressors, and engines, where hose flexes to absorb machine vibration and other movement. Failure, if it occurs, is often near end fitting, because bending there is most severe; but it can occur anywhere along hose. Failure is usually one or more circumferential cracks that propagate in the valleys of the corrugation. Cracks are sometimes in crest of corrugation but almost never in sidewall.

Longer hose lengths and more generous bend radii will help avoid flexure fatigue. A longer braid sleeve, short length of interlock-guard hose, or spring-wire guard will reduce bending at an end fitting. A more fatigue-resistant

hose material, such as stainless steel (in preference to mild steel or bronze) also will help, as will corrugations with thinner walls—and more of them per inch of hose. Changes in corrugation shape can also improve fatigue resistance.

Resonance of a hose in sympathetic vibration with the machine to which it is attached can cause rapid failure in flexure, but most industrial applications have low exciting frequencies, and the hoses—being relatively heavy and mechanically strong—have resonant frequencies safely above these levels. Exceptions are high-speed equipment such as gas turbines, where driving and harmonic frequencies can easily cause resonance and true vibration fatigue in a hose.

If resonance is a problem, change mass of the hose, spring rate, length, or damping characteristics to avoid sympathetic vibration. Multiple-ply hose will effectively damp most resonant vibrations. Often a shorter, heavier or stiffer hose will solve the difficulty.

Vibration fatigue results from high-frequency (generally over 30-60 cps) low-amplitude motion induced by machine vibration or excessive flow velocity past internal corrugations. Presence of high-frequency vibrations usually indicates that resonance could occur. Turbines, aircraft and missiles are most susceptible.

Failure is often of a disintegrating type. Cracks can occur in any portion of the hose and frequently propagate into the corrugation sidewall. They are extremely irregular; minor cracks propagate from major ones, and their terminations often form a "Y." Occasionally, pieces break off from the hose wall, giving impression that the metal has crystallized (or is made from brittle materials.) Actually, brittle material is never used for metal hose, and there is rarely any noticeable change in the metal microstructure during failure. It usually shows abrasion (caused by the braid) along tops of convolutions.

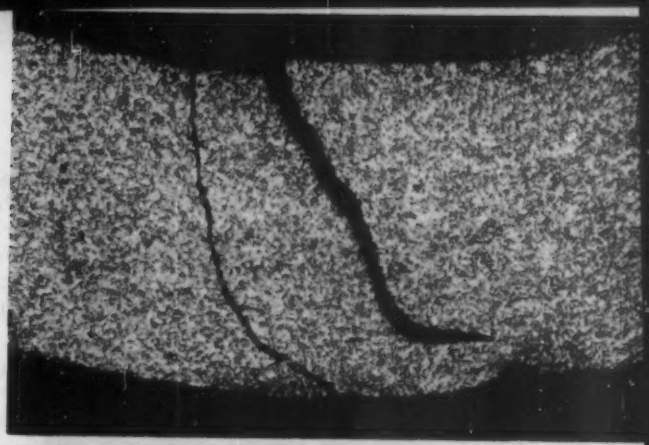
Flow velocities in excess of 150 fps can induce resonance, causing vibration fatigue in a corrugated hose even though the machine is motionless. Several answers are possible: larger diameters will reduce velocity; multiple-ply hose can be considered; smooth-surface interlocked hose can be used as a liner; or interlocked hose can be substituted for corrugated type. Interlocked hose for flow velocities faster than speed of sound have proved very satisfactory in some applications.

Resonance, if it exists, is often difficult to eliminate without compromising some other design requirements; trial-and-error testing of prototype assemblies may be necessary. For aeronautical metal-hose applications, qualification tests of prototype assemblies under simulated conditions of pressure, temperature, flow and vibration, are common.

Simple torsion fatigue results from twisting the hose at low frequency. No metal hose is designed to withstand torsion.

Failure somewhat resembles that for simple flexure: it is a simple crack without the radiating branches characteristic of vibration-fatigue failure. However, it is usually curved, angles through the metal, and may extend from valley to crest up the sidewall of the corrugation.

The twisting force involved might be simple torque applied to one of the two end fittings, but it is more likely that compound motion is involved. For example, if a hose is installed in a bent position, then lateral movement



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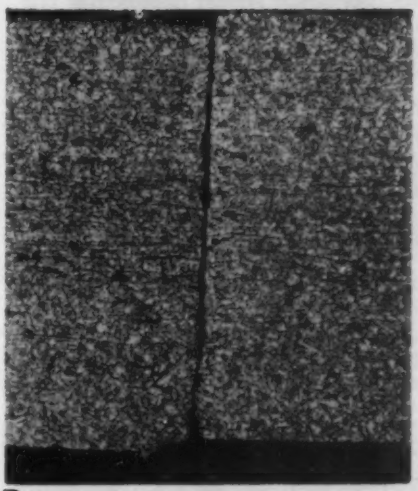

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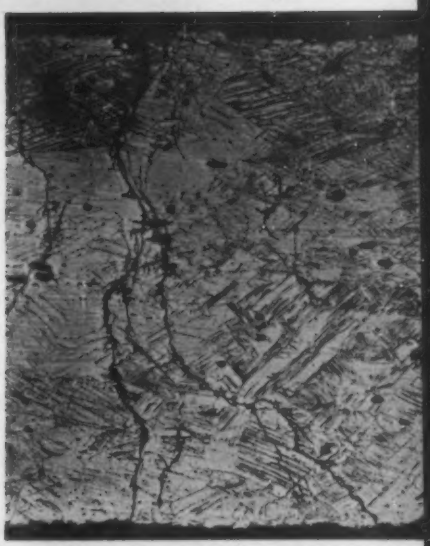


C

METALLURGY OF THE FAILURE

Photomicrographs (100X) of transverse section of failed corrugated-metal hose show differences among fatigue failures: simple-torsion fatigue failure (A)—(cracks proceed at angle across wall); simple-flexure fatigue failure (B)—(crack goes straight across wall); and stress-corrosion failure (C)—(in this example of austenitic stainless steel, cracks have numerous branches, which progress across grains at an angle.)

of one end, unless it is in the plane of the bend, will tend to twist the hose. Or, if a straight run of hose must be twisted to align the end flanges during installation, then any lateral flexure during operation will further torque the hose. Torsion during installation can be avoided by specifying a floating flange or union on at least one end of the hose assembly.

Pressure-cycling fatigue results from repetitive pressure surges inside the hose. The convolutions of corrugated hose, being more rigid in radial direction, tend to "breathe" axially. Liquids easily transmit such surges, but shock waves in gases are rarely severe enough to cause true pressure-cycling fatigue (see "Internal Pressure," p 48). Failure is undistinguishable from that for simple flexure, except that it occurs anywhere along hose, rather than mostly near an end fitting. It usually shows braid abrasion marks along tops of convolutions.

Most industrial applications for high-pressure hydraulics can be met with ordinary synthetic rubber hose. It has a natural resilience and damping action. Corrugated metal hose is not required; in fact, most types of corrugated metal hose are not recommended. In high-temperature aircraft applications (and some industrial ones), where synthetics are not suitable and corrugated metal hose is the only answer, there is available (from Flexonics Corp) a special multiple-ply metal hose for 3000-psi shock service. Peak pressures can be as high as 4500 psi, and rate of pressure increase can be over 200,000 psi per second.

CORROSION

Corrosion failures in metal hose are less frequent than fatigue failures, and can be prevented in most instances by proper material selection. Consider the corroding medium present, service temperature, and period of exposure.

For most hose applications, suitable metals can be selected from the table on next page. Very special materials have been used, too, but at considerably higher cost. For example, Inconel "X," Rene 41, Haynes 25, Hastelloy C, and commercially pure titanium have been made into both hose and bellows. For more detailed information, exhaustive tables of corrosion resistance and other characteristics for most hose materials are available from hose manufacturers.

Of typical materials shown in table austentic stainless steels provide best combination of corrosion resistance and elevated-temperature strength. The special table of corrosion-resistant austenitic steels shows the merits of some types.

Here are explanations of what various corrosion terms mean, and how the correct choice of hose material and design can prevent failure.

Intergranular corrosion in austenitic stainless steel is caused by chromium carbide precipitation at elevated temperatures—800 to 1500 F—followed by exposure to a corrosive medium. Loss of corrosion resistance at the grain boundaries occurs. By "stabilizing" the carbon with titanium (or columbium plus tantalum), as in Types 321 and 347, titanium or similar carbides are precipitated leaving the steel with its inherent corrosion-resistance. Lowering the carbon content sufficiently, as in Type 316*L*, also assures resistance to intergranular corrosion. Intergranular corrosion will not be a problem in most applications.

Pitting corrosion (or oxygen-concentration-cell corrosion) may occur on exposure to some of the halides—chlorides being the most frequent cause. However, iron particles and other foreign material embedded in the surface also can cause pitting. Free-iron contamination from fabrication can be removed prior to service by a "passivation" treatment which also improves the protective oxide for greater resistance to general corrosion.

Stress corrosion causes cracks in stainless steels. It is due to tensile stress in the presence of certain chemicals, particularly chlorides. In addition, there must be an aqueous phase, a temperature of 120 F or higher, and oxygen. The cracks are easily recognized, possessing numerous branches and progressing across the grain (in stabilized stainless steels). They tend to proceed at an angle rather than directly across the wall thickness, differing from routine fatigue failures in this respect.

Stress corrosion (season-cracking) in copper-base alloys—causing intergranular cracks—is sometimes a serious cause of failure in service, depending on the alloy and service environment.

Dezincification—the leaching away of zinc on exposure to water—may occur in the copper-base alloys containing appreciable amounts of zinc. But Grade A and Grade E phosphor bronze, having no zinc, are not bothered by either dezincification or stress corrosion.

Corrosion-accelerated fatigue in low-carbon steel reduces the fatigue life because sharp, deep pits become origin of cracks. Without fatigue, the pits would tend to be saucer-shaped. Pitting in low-carbon steel is hastened by presence of dissolved oxygen.

Carburization (pickup of carbon at the metal surface at elevated temperatures) drastically reduces corrosion resistance of austenitic stainless steels. Cause of carburization may be exposure to certain nonoxidizing atmospheres or the presence of organic compounds on the surface. Nitriding (pickup of nitrogen at the metal surface) is also detrimental in a hose.

Cavitation-erosion is mechanical damage from alternate formation and collapse of vapor cavities in moving liquid, with resulting high shock forces that wear away the metal. Photo (E), p 44, shows carbon-steel hose in which corrugation valleys have been completely worn away. Austenitic

HOW A HOSE FLEXES

Corrugated hose is essentially metal tubing that is convoluted for flexibility. Without a restraining braid, its characteristics resemble those of a bellows or spring. Flexibility depends on material used, spacing of corrugations, their shape, and approximately on the third power of their height and wall thickness. Pressure rating of the convoluted tube is generally inversely related to flexibility. For purposes of calculation however, assume that it varies as square of wall thickness. With multiple-ply hose, changes in flexibility and pressure rating can be estimated by assuming they depend on sum of the squares of each ply thickness. Thus, a corrugated hose with two 0.01-in. plies has twice the flexibility and half the pressure capability of a single 0.02-in. ply.

stainless steels resist such erosion better than carbon steel and possibly bronze. Any hose will last longer if velocities are reduced.

TEMPERATURE

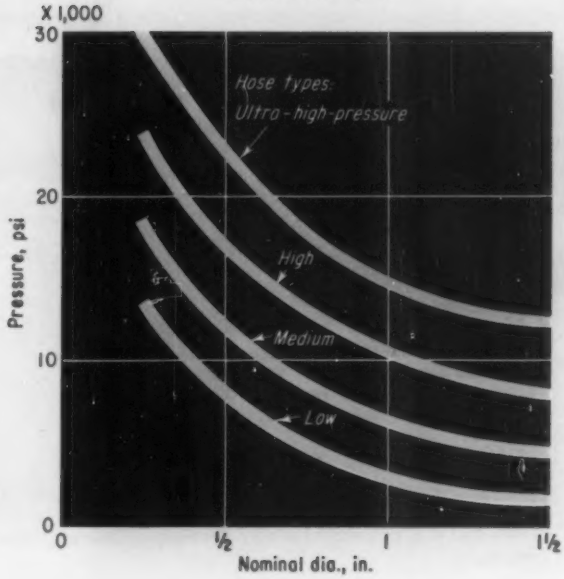
Temperature standards for hose materials are being worked on by the ASME (American Society of Mechanical Engineers) and important limitations are thoroughly discussed in previous articles (see Editor's note).

Continuous temperatures can be at the high limits proposed by the standards for the various materials involved. **Cycling temperatures** (of the contained fluid or of the surrounding atmosphere) can have peaks that are higher, so long as the temperature of any part of the hose does not exceed its limiting value. Longer hose-assembly life is insured if peak temperatures are kept at or below recommended steady-state values.

Special high-temperature stainless steels—types 309 and 310—resist oxidation to 2000 F and are useful in those rare applications where such temperatures are encountered. Type 321 and 316L—considered standard for metal hose—have reasonable oxidation resistance to 1500 F which is usually adequate. (Table shows strength at various temperatures for type 321.)

For very low-temperature operation (below −40 F) austenitic stainless steel (like type 304, 321, or 316L), copper, and phosphor bronze are best. They are free from

Burst Pressures for Metal Hose (Typical Ranges)



TYPICAL MATERIALS FOR METAL HOSE EXPANSION JOINTS AND BELLOWS

Material	Application		
	Hose	Expansion Joints	Bellows
Carbon steel (SAE 1010)	✓		
Copper		✓	
Brass (80–20)			✓
Phosphor bronze: grade E	✓		
grade A			✓
Beryllium copper 25			✓
Stainless steel (austenitic) 304		✓	
316		✓	✓
316L	✓		✓
321	✓	✓	✓
347			✓
Monel			✓

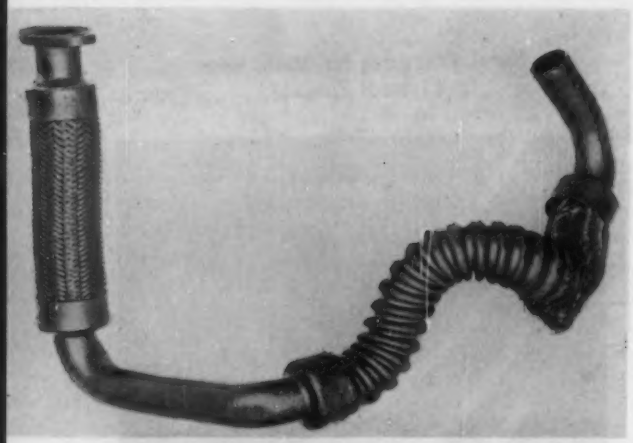
CORROSION RESISTANCE OF AUSTENITIC STAINLESS STEELS

Type	Alloying elements, % (approx)				Primary characteristics
	carbon (max)	chromium	nickel	other	
304	0.08	19	10		basic austenitic type
316	0.08	17	12	Mo 2.5	resists chlorides
316L	0.03	17	12	Mo 2.5	
321	0.08	18	10	Ti 5 × *C	free from intergranular corrosion
347	0.08	18	11	Cb + Ta 10 × C	

*5 x C means 5 times minimum carbon content

STRENGTH OF STAINLESS STEEL (type 321)

Temp, °F	Yield, psi	Ultimate, psi
70	33,000	82,500
300	29,000	68,000
500	26,000	62,000
700	23,000	60,000
900	20,500	58,000
1100	19,000	50,000
1300	16,500	36,500
1500	13,000	22,000



BURST PRESSURE was exceeded in this vibration-absorbing hose. The braid—normally depended on for end restraint—was first to fail. Then the inner hose buckled, elongated and ruptured.

low-temperature brittleness. This is not true for low-carbon steel, and it is not recommended for such subambient temperatures.

INTERNAL PRESSURE

Safe containment of pressure and unrestricted passage of fluid are the primary purposes of almost any piping assembly—including flexible hose. Flow resistance depends on shape and smoothness of internal surfaces. Pressure ratings listed for different hose types in most manufacturers' catalogs, are based on varying assumptions and conditions, and are meaningful only if interpreted properly. Both flow and pressure are thoroughly discussed in recent articles (see Editor's Note).

Continuous pressure—a rating recommended by manufacturer for continuous operation—is always much less than burst pressure, and is dependent on hose diameter, temperature, material, amount of flexing, corrosion, fluid velocity, vibration, pressure cycling and many other conditions. A safety factor is always allowed—3:1, based on hose assembly burst pressure (at given operating temperature) is a typical value.

Pulse and shock pressures must be lower than rated continuous pressures. It is difficult to define the difference in meaning between pulse and shock, so if possible provide the manufacturer with an oscillograph plot (or equivalent) of the impulse you expect. Military specification *MIL-H-8788A* (available from Government Printing Office, Wash, DC) and others for high-pressure synthetic hose avoid controversy by outlining the shock wave in detail including rate of pressure rise (psi per second), peak pressure (percent of operating), and number of cycles a hose assembly must withstand to qualify for certain aircraft uses.

Pulse pressures generally occur when fluid is a high-velocity gas and is shut off rapidly (its compressibility helps prevent shock). If pulse-type pressures are expected, it is usual to rate the hose at one-half normal operating pressure.

Shock pressures (more severe than pulse pressures) are likely to occur if the fluid is a liquid and is controlled with quick-acting valves. In small systems, a solenoid valve is fast enough to cause shock; in pipelines 500 feet long, even a slow-acting valve (several seconds to operate) will cause shock. Valves that are slow-acting will usually prevent shock in any system. Where there is likely to be frequent shock, usually rate ordinary corrugated-metal hose at $\frac{1}{8}$ normal operating pressure. If frequency is negligible, rating it at $\frac{1}{2}$ normal operating pressure may be permissible.

EXTERNAL ABUSE

Abuse is often a primary consideration in selecting a metal hose for many industrial applications. Hose is frequently overbent, crushed, abraded, pierced, overheated, accidentally burned through, or pulled apart. Even under such conditions, good service life is often possible if hose constructions such as these are chosen:

TYPE OF ABUSE	SOME RECOMMENDED CONSTRUCTIONS
Overbending	Over-all interlocked-hose guard.
Crushing	Thicker wall and stronger alloy, such as austenitic stainless steel.
Abrading	Over-all heavy, spiral-wire guard, or in some cases a synthetic covering.
Piercing	Over-all interlocked-hose guard.
Overheating	More heat-resistant alloy, such as austenitic stainless steel. For short-time, ultrahigh temperature protection (such as accidental burnthrough): insulation and a stainless-steel interlocked-hose guard.
Pulling apart	Multiple or higher strength braids for more strength in tension.

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, NY.

ACKNOWLEDGEMENT

This article comes direct from Flexonics Corporation's experience with service failures. Its frankness is due to the author's (and his company's) willingness to publicize the universal problem of hose failures so that steps can be taken to prevent them. Some of the material on fatigue and corrosion was supplied by R. H. Schark, senior metallurgist.

EDITOR'S NOTE: Metal hose performance and design standards are detailed in these previous articles that complement the one in this issue:

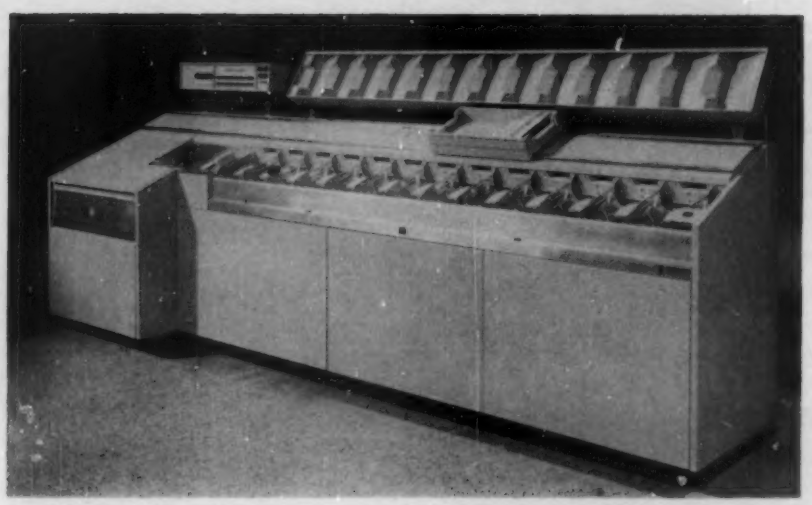
Standards for Metal Hose, Apr 11 '60, p 62—Comprehensive new standards that help define working limits and design features for both interlocked (all types) and corrugated hose. Given are ways to calculate burst pressure, and correct it for temperature, shock and end-fitting design.

Pressure Losses in Flexible Metal Tubing, Apr '56, p 223—Quick method for estimating pressure drop through corrugated metal hose.

Metallurgical reasons why hose metals behave as they do under stress and adverse environments are given in these two articles:

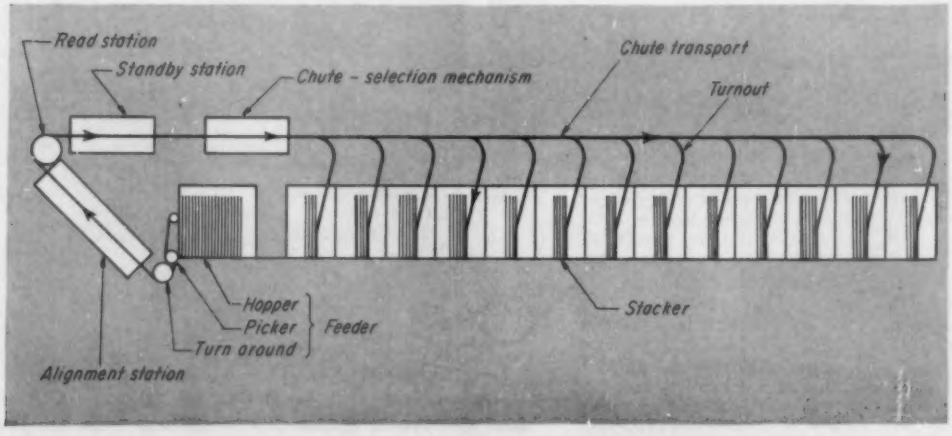
Thermal-stress Fatigue, June '57, p 175—Shows how fatigue and shock can result from temperature fluctuations, and how performance can be predicted for metals and ceramics under such conditions.

Stress-corrosion in Metals, Aug 4 '58, p 56—Explains how stress plus chemical environment can make it tough for some alloys to resist cracking, and why electrolytic migration might be part of the cause.



Sorter-Reader Handles Checks in a Hurry

Papers, coded with magnetic ink, are accurately positioned, read and sorted into proper bins—all at speeds of 400 in. per sec.

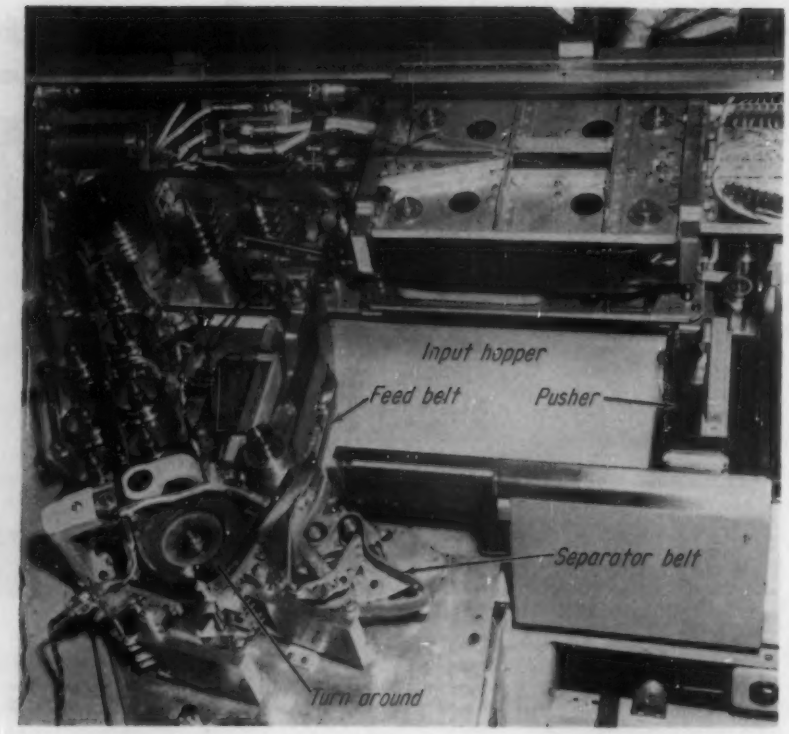


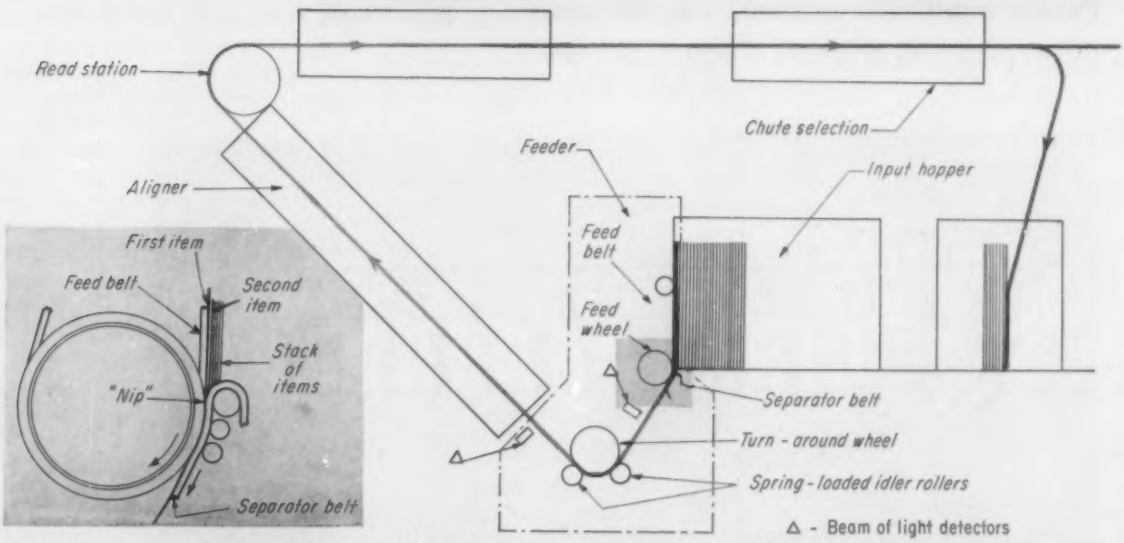
PROCESSING STARTS when items to be sorted (checks or other bank documents) are placed in hopper, bottom edge down, facing left. A feeder picks the items from the hopper, one at a time, in an edge-to-edge sequence. For a simple sorting operation, the items are picked at a speed of 150 in. per second. The picker transports the items to the turn-around drum which accelerates them to a speed of 400 in. per sec. This acceleration gives the proper spacing for reading and prevents overlap of successive pieces. The turn-around drum discharges into the aligning station, which positions the items to a bottom-edge reference in preparation for reading.

After it has been read the item passes to the chute-selection mechanism. While the item is moving from the reader to the chute-selection station, the control logic of the sorter selects the chute path indicated during the read operation to deliver the item to the desired pocket. There are 13 separate item-paths between the chute selector and the 13 pockets. A stacker mechanism in each pocket stacks the checks so they can be unloaded while the machine is operating.

The standby station stops the items and prints a batch number on the back of each. This is used when the sorter-reader is integrated with other equipment for automatic bookkeeping.

Sorter Reader continued

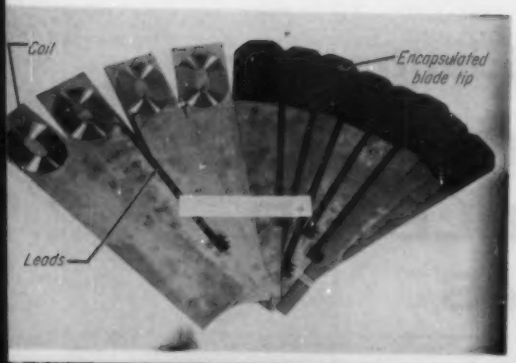


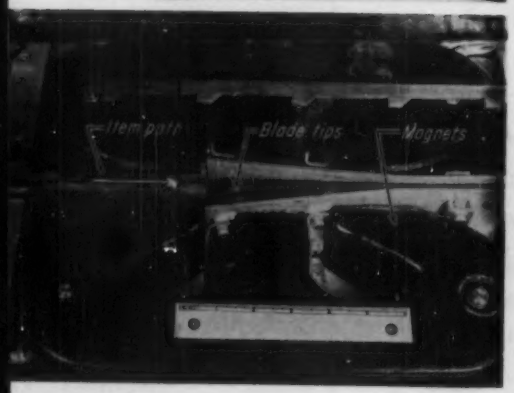


INPUT HOPPER can feed jogged items continuously or bundles of unjogged items up to 2½ in. thick. Continuous feed is accomplished by using a two-part pusher, which permits stacks of jogged items to be added while uniform feed pressure is maintained on the first batch. Pusher is driven by a permanent magnetic-hysteresis clutch to maintain constant force between first item and feed belt.

The picker consists of a feed belt and wheel plus a separator-belt unit. The feed belt advances the first item until it is caught in the "nip" between the feed wheel and separator belt. The item continues to accelerate, driven by the feed wheel while slipping on the surface of the slowly moving separator belt. A high friction elastomer provides a high coefficient of friction between the feed wheel and paper. A high-density urethane foam provides a frictional coefficient lower than the feed-wheel-to-paper coefficient and higher than the item-to-item coefficient. These characteristics permit the first item to be driven by the feed wheel while successive items are retarded by the separator belt until the first item has left the nip. This produces edge-to-edge delivery of successive items to the turn-around.

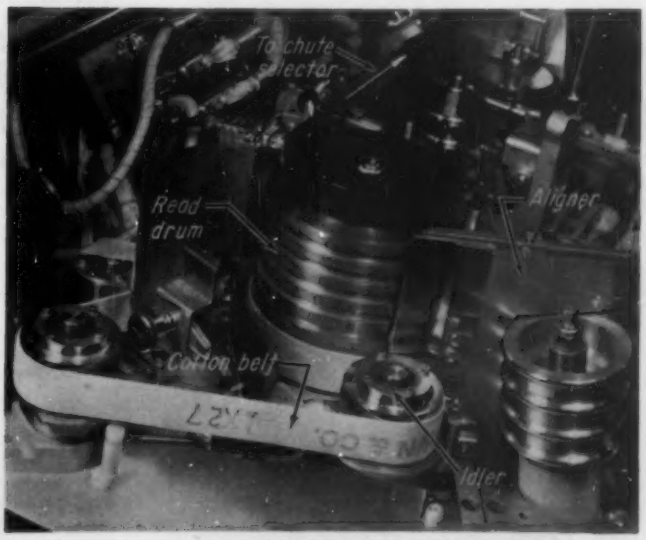
The turn-around is a 4½-in.-dia wheel with two sets of spring-loaded idlers running against it. When the leading edge of an item enters the nip of the turn-around wheel and first set of idlers, it is traveling at 150 in. per sec. When the trailing edge leaves the nip of the feed wheel, the item is accelerated to 400 in. per sec. This acceleration pro-

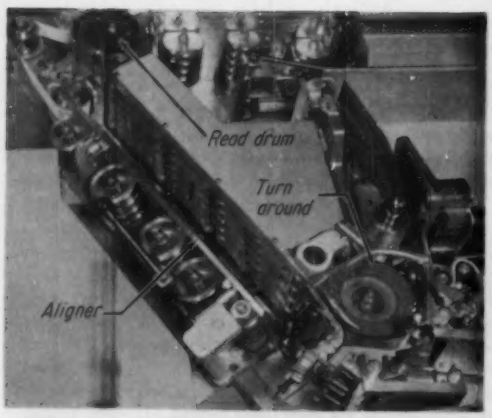




CHUTE-SELECTION mechanism consists of four permanent magnets and 12 pairs of chute blades. A wire coil is bonded to each blade tip and encapsulated. When a pocket is selected at the read station, current applied to the coils reacts with the magnetic field to swing the flexible blades aside and open the proper chute. The direction in which current flows in the chute blade coil determines the direction of chute-blade motion. A low current through the coils holds the blades in position while the item passes the blade tips. Average time for chute blades to open a path for an incoming item is 15 milliseconds. Twenty milliseconds is the maximum allowable time.

Each chute-blade set consists of an upper and lower blade which extends from the chute selector to a designated pocket. Items are transported through the chute selector and chute by a fabric belt which runs in the gap between the upper and lower blade sets. The item is held against the moving belt by a series of rollers and spring-loaded idlers. When the item reaches the selected pocket, a turnout on the chute blade directs the item to the pocket where it is stacked for collection by the operator.



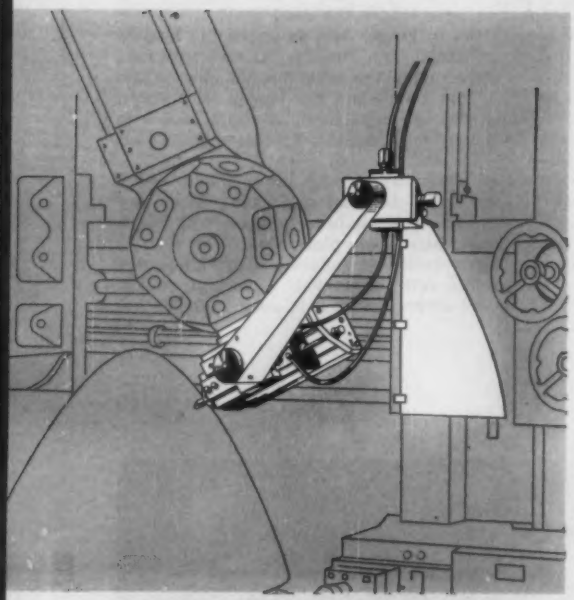


vides the spacing required for reading and sorting, and eliminates overlap of successive items.

Items leaving the turn-around enter the aligner where they are aligned to within 1/32 in. of their common bottom-registration surface over their entire length. Alignment and transport is accomplished by means of a series of roller pairs which tend to drive the items against the registration edge as they are transported forward. Five sets of drive rollers are used. The first set is rubber-to-metal to provide a positive grip, the next four sets are tilted to the item path to drive the item down toward the registration surface. The first set is tilted 15°, the next three sets 10°. They drive the item with a corrugating type of grip. This drive permits slippage on the item surface relative to the axis of the rollers. Phosphor-bronze leaf springs are used to bridge the roller openings in the aligner-guide plates to prevent items from tripping.

The reading station accepts items from the aligner and transports them over magnetizing and reading heads while maintaining a speed of 400 in. per sec. The item contacts the read drum for 120° and is held against the rotating drum by a spring-loaded cotton belt running on idlers. The magnetizing and reading heads are encapsulated in a stationary read drum concentrically mounted beneath the rotating drum. The lower edge of the item being read overhangs the edge of the rotating drum and is held in contact with the read drum by a pressure tape of non-magnetic stainless steel. Items from the read station pass through the standby station to the chute selector.

PS . . . Sorter-reader handles bank documents, coded with magnetic ink, at speeds up to 1560 items per minute. Mixed items of varying sizes and thicknesses may be fed into and removed from the unit while sorting continues. Unit can be used separately or as the input mechanism for conversion and computer systems. Sorter–Reader, Style B101 was developed by Burroughs Corp, Research Center, Paoli, Penna and produced at the Burroughs Plymouth Div.



TRACER MACHINE for missile nose shows tapered tracer arm similar to one in example given on page 55.

new equations for

5 TAPERED CANTILEVER BEAMS

Calculating the stresses and deflections in these weight- and money-saving beams used to involve differential equations. Now, you just need simple algebra, thanks to the author's new equations.

W R PETRI, *consulting engineer*
Dominion Aluminum Fabricating Ltd
Toronto, Canada

SYMBOLS

A – Area, sq-in.
a_n – Area constant
C_n – Moment-of-inertia constant
C_1, C_2 – Constants of integration
D – Shear modulus, psi
E – Modulus of elasticity, psi
e – Center of gravity distance, in.
F – Force, lb
G – Weight, lb
I – Moment of inertia, in^4
L – Beam length, in.
M_B, M_S, M_T – Moments (bending, shear, torsion), in.-lb
P – pressure, psi
q – Weight per unit volume lb/in^3
R_e, R_L – Radius (end, base), in.
S_B, S_S, S_T – Stress (bending, shear, torsion), psi
t – Thickness, in.
u – Unit cross-section length, in.
V – Volume, in^3
W – Resultant load, lb
w – Load per unit length, lb/in.
X, Y, Z – Axis
Y_e – Deflection at end, in.
β – Angle of slope of beam
γ – Angle of deflection
ψ – Angle of torsional deflection
ρ – Radius of curvature
ϵ – R_e/R_L

In the past, when designing a simple cantilever beam, there has been a strong temptation to use a uniform cross-section. Yet a tapered cross-section is preferable. Whatever the type of loading, a tapered hollow cantilever beam can do the job with less weight while improving functional appearance of the machine.

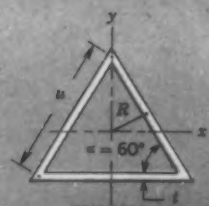
Then why this aversion to tapered cross-sections? Because they involve complex differential equations. But now we have a method that reduces these differential equations to simple algebra for five common cross-sections and six different load applications. The derivation for one type of load is also given to show how these equations may be applied to other loads and shapes.

This article gives the required constants for area, moment of inertia, unit length, and beam weight for each cross-section. It then applies these constants to equations derived for deflection, bending and shear stress under a single concentrated load, constant bending moment, wind load (or hydraulic pressure), torsional moment, uniform load and beam weight load.

Constants for each cross-section are calculated and summarized in the table on p 53. For all the constants, triangular cross-sections give the highest values and circular cross-sections the lowest. Equations show the total weight and moment of inertia will vary in direct proportion to these constants.

The summary table of derived equations for various types of loads shows how the constants for different cross-sections can be applied to determine quickly the deflection or stress at any point on the beam. These equations can also be used for constant-cross-section beams by

CALCULATION OF CONSTANTS



TRIANGLE

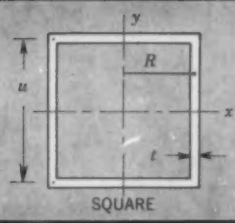
$$A = \frac{3x3Rt}{\cos\frac{\alpha}{2}} = 10.39Rt; a_0 = 10.39$$

$$u = \frac{3R}{\cos\frac{\alpha}{2}} = 3.46R$$

$$I_x = I_y = \frac{2u^3t}{12}\sin^2 120 + \frac{2t^3u}{12}\cos^2 120 + 2uR^2t\sin^2\frac{\alpha}{2} + utR^2$$

$$= 2\,\frac{27R^3t\,\sin^2 60}{12\,\cos^3 30} + 2\,\frac{t^3 3R\,\cos^2 60}{12\,\cos 30} + 2\,\frac{3R^3t\,\sin^2 30}{\cos 30} + \frac{3R^3t}{\cos 30} = 10.4R^3t$$

$C_0 = 10.4$



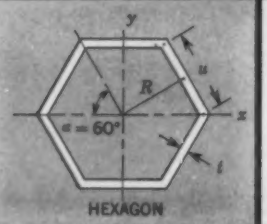
SQUARE

$$I_x = I_y = 2\times 2Rt\times R^2 + 2\,\frac{t}{12}\left(2R\right)^3$$

$$= 4R^3t + \frac{4}{3}R^3t = 5.33R^3t$$

$C_0 = 5.33$

$A = 4ut;\ u = 2R;\ A = 8Rt;\ a_0 = 8.00$



HEXAGON

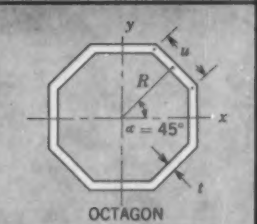
$$A = 6t \times 2R\tan\frac{\alpha}{2} = 6.930Rt;\ a_0 = 6.930$$

$$u = 2R\tan\frac{\alpha}{2} = 1.155R$$

$$I_x = I_y = 4tR\times R^2\tan\frac{\alpha}{2} + 8Rt\left(\frac{R}{2}\right)^2\tan\frac{\alpha}{2} + 4\,\frac{t}{12}R^3$$

$$= R^3t\left(4\tan\frac{\alpha}{2} + 2\tan\frac{\alpha}{2} + \frac{1}{3}\right) = 3.80R^3t$$

$C_0 = 3.80$



OCTAGON

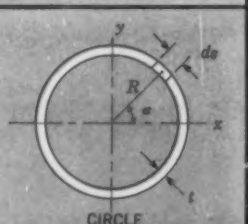
$$A = 8t\times 2R\tan\frac{\alpha}{2} = 6.636Rt;\ a_0 = 6.636$$

$$u = 2R\tan\frac{\alpha}{2} = 0.828R$$

$$I_x = I_y = 2\left[2tR\times R^2\tan\frac{\alpha}{2} + 4tR\tan\frac{\alpha}{2}\left(R\sin\frac{\alpha}{2}\right)\right] + 2\,\frac{t}{12}\left(2R\tan\frac{\alpha}{2}\right)^3$$

$$= 4R^3t\tan\frac{\alpha}{2}\left(1 + 2\sin^2\alpha + \frac{1}{3}\tan^2\frac{\alpha}{2}\right) = 3.40R^3t$$

$C_0 = 3.40$



CIRCLE

$A = 2\pi Rt = 6.28Rt;\ a_0 = 6.28$

$dI_x = t(R\sin\alpha)^2 ds;\quad ds = Rd\alpha$

$dI_x = tR^3\sin^2\alpha\, d\alpha$

$$\tfrac{1}{4}\ I_x = tR^3\int_{\alpha=0}^{\alpha=\frac{\pi}{2}}\sin^2\alpha d\alpha = \frac{\pi}{4}tR^3$$

$I_x = I_y = \pi R^3t \qquad C_0 = 3.14$

For All Cross-Sections: $G = \frac{a_0}{2}qLt(R + R_0);\quad I_x = C_0R^3t$

substituting $R = R_a = R_b$, thus obtaining a quick, useful comparison between tapered and uniform cross-section.

Although these equations are easy to apply, their derivation is not so simple. However, if you are thinking of some other cross-section or loading, it can be helpful to see how some of these equations were derived.

DERIVATION FOR CONCENTRATED LOAD

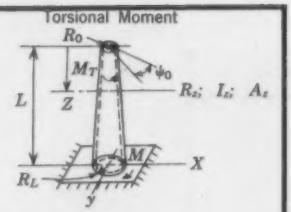
Referring to sketch, "Concentrated Load at End," p 54, the bending moment is $M_x = FZ$, and the function for the radius of curvature is:

text continued next page

SUMMARY OF CONSTANTS

Cross-section	a_o	C_o	u
Triangle	10.39	10.40	3.46 R
Square	8.00	5.33	2.00 R
Hexagon	6.93	3.80	1.155R
Octagon	6.64	3.40	0.828R
Circle	6.28	3.14	.....

Torsional Moment



$$\psi_0 = \frac{-M_T L\,(R_L + R_0)}{4DtC_0R_L^2R_0^2}$$

$y_0 = 0$

At top $S_B = 0$

At bottom $S_B = 0$

At top $S_s = \dfrac{M_T}{2tC_0R_0^2}$

At bottom $S_s = \dfrac{M_T}{2tC_0R_L^2}$

Concentrated Load at End

$$\gamma = \frac{-F}{2EtC_0R_0}\left(\frac{L}{R_L}\right)^2$$

$$y_0 = \frac{2F}{3EtC_0}\left(\frac{L}{R_L + R_0}\right)^3\left\{1 + \frac{3}{4}\left(1 + \frac{R_0}{R_L}\right)\right\}$$

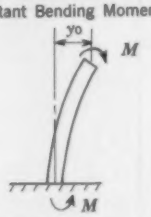
At top $S_B = 0$

At bottom $S_B = \pm\dfrac{FL}{tC_0R_L^2}$

At top $S_s = \dfrac{4F}{3a_0tR_0}$

At bottom $S_s = \dfrac{4F}{3a_0tR_L}$

Constant Bending Moment



$$\gamma = \frac{-M_BL(R_L + R_0)}{2EtC_0R_L^2R_0^2}$$

$$y_0 = \frac{M_B}{2EtC_0R_0}\left(\frac{L}{R_L}\right)^2$$

At top $S_B = \pm\dfrac{M_B}{C_0tR_0^2}$

At bottom $S_B = \pm\dfrac{M_B}{C_0tR_L^2}$

At top $S_s = 0$

At bottom $S_s = 0$

Symbols shown in torsional moment diagram also apply to the others where called for in equations. All sections are measured from top.

$$y'' = \frac{1}{\rho} = \frac{d^2y}{dZ^2} = \frac{M_B}{IE} = \frac{FZ}{EtC_e(R_e + Z\tan\beta)^2}$$

The function for the angle of deflection at any point along the beam is

$$y' = \frac{dy}{dZ} = \frac{F}{EtC_e}\int\frac{ZdZ}{(R_e + Z\tan\beta)^2}$$

Integration gives:

$$y' = \frac{F}{EtC_e}\left\{\frac{1}{\tan^2\beta}\left[\frac{R_e}{2(R_e + Z\tan\beta)^2} - \frac{1}{R_e + Z\tan\beta}\right] + C_1\right\}$$

When

$$Z = L, \quad y' = 0 \quad \text{and} \quad R_e + Z\tan\beta = R_L$$

Hence:

$$C_1 = \frac{1}{\tan^2\beta}\left[\frac{1}{R_L} - \frac{R_e}{2R_L^2}\right] = \frac{1}{R_L\tan^2\beta}\left[1 - \frac{R_e}{2R_L}\right]$$

The function for the angle of deflection now is:

$$y' = \frac{F}{EtC_e\tan^2\beta}\left\{\frac{R_e}{2(R_e + Z\tan\beta)^2} - \frac{1}{R_e + Z\tan\beta} + \frac{1}{R_L}\left(1 - \frac{R_e}{2R_L}\right)\right\}$$

When

$$Z = 0, \quad y' = \gamma_e \quad \text{and} \quad R_e + Z\tan\beta = R_e$$

Hence:

$$\gamma_e = \frac{F}{EtC_e}\left(\frac{L}{R_L - R_e}\right)^2\left\{\frac{R_e}{2R_e^2} - \frac{1}{R_e} + \frac{1}{R_L} - \frac{R_e}{2R_L^2}\right\}$$

$$\gamma_e = \frac{FL^2}{EtC_e(R_L - R_e)}\left\{-\frac{1}{2R_eR_L^2}(R_L - R_e)^2\right\} = -\frac{F}{2EtC_eR_e}\left(\frac{L}{R_L}\right)^2$$

The deflection at any point along the beam is:

$$y = \frac{F}{2EtC_e\tan^2\beta}\left\{R_e\int\frac{dZ}{(R_e + Z\tan\beta)^2} - 2\int\frac{dZ}{R_e + Z\tan\beta} + \frac{2}{R_L}\left(1 - \frac{R_e}{2R_L}\right)\int dZ\right\}$$

$$y = \frac{F}{2EtC_e\tan^2\beta}\left\{-\frac{R_e}{\tan\beta(R_e + Z\tan\beta)} - \frac{2}{\tan\beta}\log(R_e + Z\tan\beta) + \left(\frac{2}{R_L} - \frac{R_e}{R_L^2}\right)Z + C_2\right\}$$

$$y = \frac{F}{2EtC_e\tan^2\beta}\left\{-\frac{R_e}{R_e + Z\tan\beta} - 2\log(R_e + Z\tan\beta) + \tan\beta\left(\frac{2}{R_L} - \frac{R_e}{R_L^2}\right)Z + C_2\tan\beta\right\}$$

When

$$Z = L, \quad y = 0 \quad \text{and} \quad R_e + Z\tan\beta = R_L$$

$$C_2\tan\beta = \frac{R_e}{R_L} + 2\log R_L - \frac{R_L - R_e}{L}\left(\frac{2}{R_L} - \frac{R_e}{R_L^2}\right)L$$

$$C_2\tan\beta = \frac{R_e}{R_L} + 2\log R_L - (R_L - R_e)\left(\frac{2}{R_L} - \frac{R_e}{R_L^2}\right)$$

The function for the deflection now is:

$$y = \frac{F}{2EtC_e\tan^2\beta}\left\{R_e\left(\frac{1}{R_L} - \frac{1}{R_e + Z\tan\beta}\right) + 2\log\frac{R_L}{R_e + Z\tan\beta} + \left(\frac{2}{R_L} - \frac{R_e}{R_L}\right)(Z\tan\beta - R_L + R_e)\right\}$$

But the deflection is most important at the end of the beam, so when

$$Z = 0, \quad y = y_e \quad \text{and} \quad R_e + Z\tan\beta = R_e$$

Hence:

$$y_e = \frac{F}{2EtC_e\tan^2\beta}\left\{R_e\left(\frac{1}{R_L} - \frac{1}{R_e}\right) + 2\log\frac{R_L}{R_e} - \left(\frac{2}{R_L} - \frac{R_e}{R_L^2}\right)(R_L - R_e)\right.$$

After further simplification this becomes

$$y_e = \frac{2F}{3EtC_e}\left(\frac{L}{R_L - R_e}\right)^3\left\{\frac{3(R_L + R_e)^2}{4R_L^2} + 1\right\}$$

$$y_e = \frac{2F}{3EtC_e}\left(\frac{L}{R_L + R_e}\right)^3\left\{\frac{3}{4}\left(1 + \frac{R_e}{R_L}\right) + 1\right\}$$

The bending stress at the base is:

$$S_B = \pm \frac{FL}{tC_oR_L^3}$$

The shearing stress is at base:

$$S_S = \frac{4F}{3A} = \frac{4F}{3a_otR_L}$$

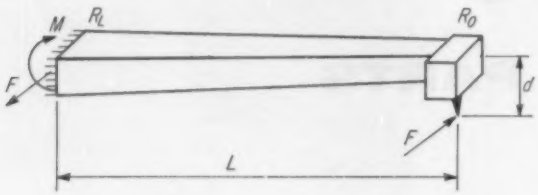
at top:

$$S_S = \frac{4F}{3a_otR_o}$$

Example—a Tracer Arm

A forming machine for missile nosecones requires a cantilever beam for the tracer unit. To maintain accuracy, the tracer arm must not deflect more than 0.0005 in. under hydraulic load of tracer unit. It is desirable to have a square cross-section to accommodate the tracer unit with dimensions shown in sketch and other data given as follows; calculate the thickness of the tracer arm.

Tracer Arm for Missile Nosecone



Data given:

Stylus Force $F = 3$ lb.; $R_L = 4$ in.; $R_o = 2$ in.
$\epsilon = 0.5$; $L = 72$ in. $d = 10$ in.
Material: Steel

Solution

$$M_T = 3 \times 10 = 30 \text{ in.-lb.}$$

For square cross-section $a_o = 8.00$; $C_o = 5.33$ (from table).

The max deflection given in this case is the sum of deflection due to stylus force at the end of the beam and deflection due to torsional force, or

$$y_T = y_1 + y_2 = 0.0005 \text{ in.}$$

The equations from summary table are:

$$y_1 = \frac{2F}{3EtC_o}\left(\frac{L}{R_L + R_o}\right)^3\{1 + \tfrac{3}{4}(1+\epsilon)^2\}$$

$$y_2 = \psi_o d = d\,\frac{M_T L(R_L + R_o)}{4DtC_oR_L^2R_o^2}$$

Since Poisson's ratio for steel = 0.3, and $E = 2.9 \times 10^7$; $D = 0.385\ E$, above equations can be combined and rearranged to solve for t:

$$t = \frac{3}{5.33 \times 2.9 \times 10^7 \times 4^3 \times 0.0005}\left[\tfrac{3}{4}\left(\frac{72}{1.5}\right)^3\left\{1 + \tfrac{3}{4}(1.5)^2 + \frac{10 \times 72 \times 1.5}{4 \times 0.385(0.5)^2}\right\}\right]$$

$t = 0.1217$ or $\frac{1}{8}$ in.

The weight of the arm is

$$G = \frac{8}{2} \times 0.283 \times \frac{72}{8}(4+2) = 76.4 \text{ lb}$$

With such small deflections the resulting stresses are negligible.

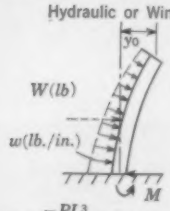
For REPRINT of above article, just check P56 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: For additional information on stress analysis see:

Faster Stress Analysis of Combined Loads on Beams, May 16 '60, p 97—Author's method avoids use of differential equations, yet gives comparable accuracy. It can be applied directly to simple beams, or extended to beams with complex loads, as well as statically indeterminate beams.

Finding Stresses in a Pressure-vessel Head, July 6 '59, p 57—Method uses strain gages, all located on outside of vessel, yet accurately determines biaxial stresses at joint of shell and head.

Hydraulic or Wind Load



$$\gamma = \frac{-PL^3}{3EtC_oR_L^2}$$

$$y_o = \frac{PL^4}{6EtC_oR_L^2}\left\{2 - \frac{1 + \left(\frac{R_o}{R_L}\right) + 2\left(\frac{R_o}{R_L}\right)^2}{\left(1 + \frac{R_o}{R_L}\right)^3}\right\}$$

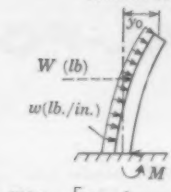
At top $S_B = 0$

At bottom $S_B = \pm \frac{P(2R_L + R_o)}{3tC_o}\left(\frac{L}{R_L}\right)^2$

At top $S_s = 0$

At bottom $S_s = \frac{4P(R_L + R_o)L}{3a_otR_L}$

Uniform Load



$$\gamma = \frac{WL^2}{3EtC_oR_L^3}\left[\frac{3}{4}\left(\frac{1}{1+\frac{R_o}{R_L}}\right) + \frac{1}{\left(1+\frac{R_o}{R_L}\right)^3}\right]$$

$$y_o = \frac{WL^3}{4EtC_oR_L^3}\left[\frac{2 + \left(\frac{R_o}{R_L}\right) + \left(\frac{R_o}{R_L}\right)^3}{\left(1+\frac{R_o}{R_L}\right)^3}\right]$$

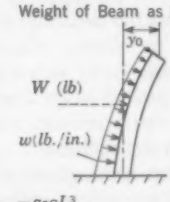
At top $S_B = 0$

At bottom $S_B = \pm \frac{WL}{2tC_oR_L^2}$

At top $S_s = 0$

At bottom $S_s = \frac{4W}{3a_otR_L}$

Weight of Beam as Load



$$\gamma = \frac{-a_oqL^3}{6EC_oR_L^2}$$

$$y_o = \frac{a_oqL^4}{12EC_oR_L^2}\left\{2 - \frac{1 + \left(\frac{R_o}{R_L}\right) + 2\left(\frac{R_o}{R_L}\right)^2}{\left(1 + \frac{R_o}{R_L}\right)^3}\right\}$$

At top $S_B = 0$

At bottom $S_B = \pm \frac{a_oq}{6C_o}\left(\frac{L}{R_L}\right)^2(2R_L + R_o)$

At top $S_s = 0$

At bottom $S_s = \frac{2}{3}qL\left(1 + \frac{R_o}{R_L}\right)$

Hydraulic or wind load, and uniform load, are figured for projected cross-sectional area which varies with taper of the beam.

The approach is different when designing with metal powder. And how much the part will cost depends not only on the kind of powder but on how much porosity you can tolerate. Here's your . . .

guide to specifying METAL-POWDER PARTS

ROBERT TALMAGE, *powder metallurgy consultant*
New Canaan, Conn, and
HERBERT L KEE, *assistant editor*

Figure in other factors beside cost of the powder when specifying a sintered part. For example, the cheapest part may likely be the one with highest porosity. But to get this savings you have to start with the higher priced powder mixes. Being stronger to begin with, they bring more strength into the mix; this allows it to be less dense (more porous) . . . and the more expensive powder becomes the money-saver in the long run.

That illustrates the need for careful appraisal when comparing powder metallurgy with rival methods. An outstanding difference is the fact that cast or wrought parts go through a molten stage but sintered parts do not. Most of their metal remains solid during sintering and therefore relatively unchanged. Such final properties as hardness and structural strength also depend on choice of material and processing method, and especially on the sintered density.

Result is: the powder techniques offer a wide choice of materials and of special metal structures. You can easily mix the prescription even in small quantities to meet a specific application.

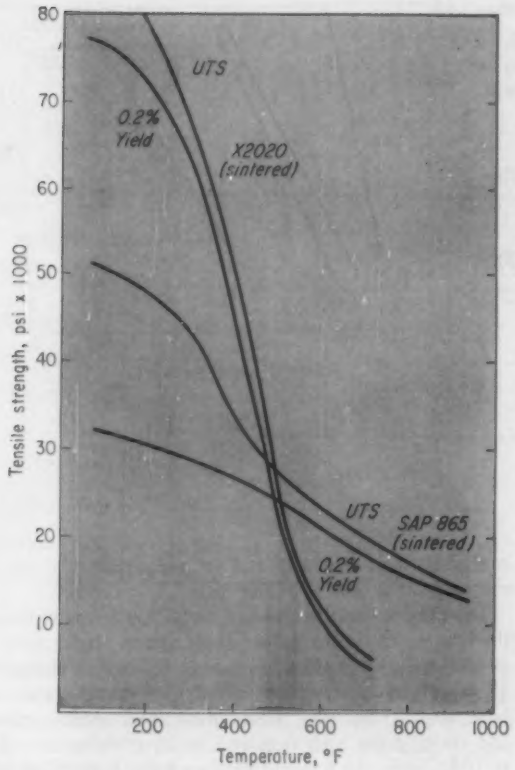
WIDE CHOICE OF MATERIALS

Metal-powder compositions are often not true alloys in the metallurgical sense; they can be just sintered-powder mixes with very little alloying between the different particles. Sintering often just activates the surface of the powder granules enough to bond them. The limited surface diffusion simplifies making metal combinations normally not soluble in each other when molten. For example, conventional steels are rarely made with more than 0.25% copper because low solubility makes the copper segregate out. On the other hand, copper content as high as 25% can be had in sintered compositions. One commercial powder mix using 5% copper increases strength of the sintered steel part 40% or more.

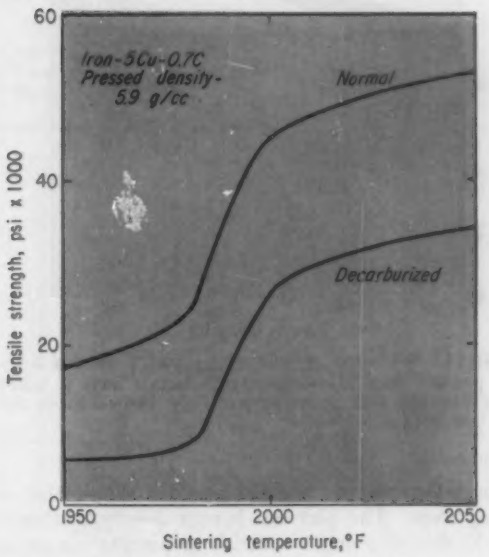
Almost any metal or metal combination can be made by powder techniques. For some, such as tungsten, pressing and sintering powder is the only commercially practical method of producing the metal. Some common powder mixes cannot normally be cast at all, for example: copper-lead alloys with as much as 40% lead uniformly dispersed; tungsten and molybdenum combined with other, lower melting metals such as copper and nickel.

The process also permits combining metals with nonmetals: graphite powder dispersed in bronze parts to provide lubrication (up to 6% graphite in bearings and 40 to 50% or more in motor brushes); tungsten and titanium carbides sintered with nickel or cobalt. Other ceramic-metal mixtures are already seeing service in high-temperature and friction applications. Self-lubricating materials such as Teflon and other plastics impregnated into metal compacts are just emerging from development.

Powder metallurgy has also extended the useful range of wrought metals. New aluminum alloys retain their strength and stability at elevated temperatures by incorporating substantial amounts of oxides that are normally considered impurities in aluminum. The Swiss SAP alloys and the newly announced Alcoa APM alloys are powders formed into billets which are then further fabricated by conventional methods such as rolling, forging, drawing or extruding. Such dispersion-hardened materials are especially stable at high temperature, and retain good creep resistance and tensile properties to 90% of the melting



STRONGER ABOVE 500 F, sintered powder extends aluminum's useful range to 1000 F. Ductility in terms of tensile elongation of the sintered materials is lower than that of the wrought material.



HIGH TENSILE STRENGTH requires close control of sintering steps, even if pressed density is consistent. Upper curve: result of sintering in good protective atmosphere. Lower curve: loss of strength from decarburizing atmosphere. Close temperature control is necessary for high strength —at 2000 F, a drop of 30 deg F can cut strength by 50%.

point—well beyond the limits of alloys made by normal melting methods. The dispersion hardening depends upon ability of the powder techniques to uniformly distribute minute particles of insoluble oxides throughout the metal.

TECHNIQUES FOR DIFFERENT STRUCTURES

Specific structures can be made by varying the "alloying" method. In sintered-metal production, "alloying" is done three ways: By mixing individual powders in the desired proportion; by alloying the metal prior to making the powder; by infiltrating a lower melting metal into an already sintered skeleton.

When mixing the individual powders, alloying depends on diffusion of essentially solid metals into one another. At normal sintering temperatures, equivalent diffusion of certain mixtures would take hours, instead of minutes by normal melting techniques. This slowness, however, permits peculiar and potentially useful structures—for example, an iron-nickel sintered part could be made with nickel-rich and iron-rich areas in the same part. On the other hand, graphite-iron mixes alloy speedily; metal-powder parts of high-carbon steel are as easily made as parts of low-carbon steel. In conventional metal-forming techniques, the reverse is true; high-carbon steels are difficult to form and fabricate, and are expensive to machine.

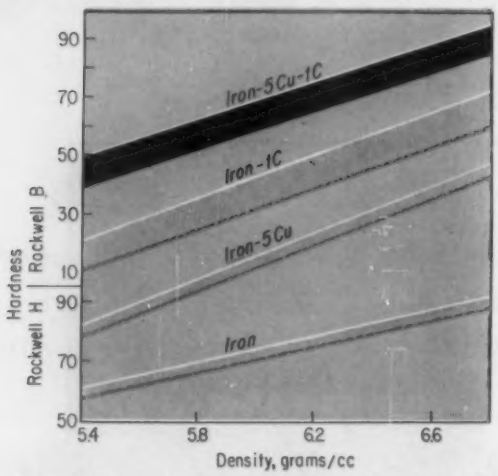
Alloying the material, then atomizing it into a powder, gives the advantage of prealloying material such as nickel and chromium which diffuse slowly at sintering temperatures. Because of this, metal-powder parts of stainless steel are usually made from prealloyed powders.

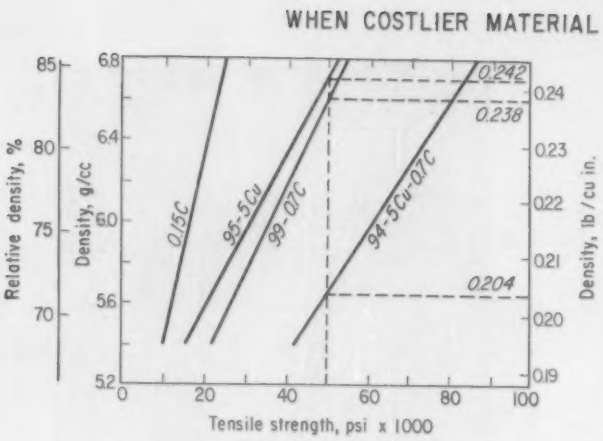
Infiltration of low melting metal into a higher-melting-point base is a simple way to eliminate unwanted porosity in a metal-powder part. In this case, the lower melting metal does go through a liquid phase. An example is copper infiltrated into iron. A piece of copper is placed on top of the iron skeleton and both are sintered above the melting point of the copper. The liquid copper then infiltrates the iron by capillary action.

Prealloyed powders and copper infiltration result normally in higher costs than by sintering of mixed powder.

POROSITY TELLS A STORY

Parts made of metal powder can be pressed to a high or a low density (that is, with a predetermined porosity) de-





HARDNESS increases linearly with sintered density for a given powder mix. Metal-powder materials have a wider hardness range than wrought materials, especially in the lower densities.

pending on compacting pressure used and the number of pressing steps. The part can have a density practically equal to that of wrought materials or porosity can be so high that the structure is barely more than a lattice with interconnected voids.

The parts with bearing surfaces are deliberately used porous so they can be impregnated with oil. This built-in reservoir gives so-called "self-lubrication." Parts are made even more porous—about 50% for filters and as high as 80%—for storage battery grids. High percentages of porosity or low relative density greatly reduce structural strength.

At the other extreme, high relative density (above 98%) gives high strength rivaling that of wrought metals. These dense sinterings, ductile and with high tensile elongation, have almost no porosity and are produced by additional pressing and sintering steps. But this substantially increases the costs of the final part so should be specified only for special purposes.

In normal practice, structural parts from a single pressing have a density range from 70 to 85% that of the solid metal. Cheapest part is the one specified within these density limits and here the higher density ones have higher mechanical properties while the lower density parts are lighter and use less powder material. Although density in the curves is also given in % density and lb per cu in., in powder metallurgy, density is usually specified as gm per cc.

THE SINTERED PROPERTIES

Tensile strengths of the low-cost sintered steels range from 10,000 psi to 90,000 psi, depending on alloy content, pressed density, sintering temperature and atmosphere. This range will meet most applications. Even when higher strength or hardness is used in a wrought material, a sintered part with a lower strength and hardness is often more than adequate. For example: "1020-steel" stampings are surface-carburized for added resistance to wear. This produces a hard surface layer with a tensile strength as high as 200,000 psi. A softer sintered metal-powder part with graphite in the mix and impregnated with oil, may have equivalent wear resistance and yet adequately take the tensile loads at as low as 25,000 psi.

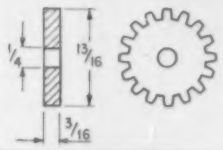
Ductility is lower in sintered metal-powder parts than in their wrought counterparts. High-carbon steels made by powder techniques often have about 1% tensile elongation. Their equivalent in conventional high-strength steel will have about 3 to 5%. Low-carbon steel, doubly pressed and sintered for high density, can have elongation of 15 to 20%, while the wrought versions have about 25 to 30%. A singly pressed part of low-carbon steel (density, 70 to 85%) would normally have elongations about 5 to 10%. In most structural applications, however, ductility is not critical when deformation prevents the part from fulfilling its function. Both a deformed part and a fractured part will cease to be useful. Metal-powder parts with low ductility have relatively high yield strength.

Fatigue strength is usually lower compared to regularly produced metals. These endurance limits are low because the angularly shaped pores act as built-in notches. (Some metal-powder parts strengthened by infiltration can have fatigue strengths in the wrought-material range.) However, metal-powder parts themselves do not have as low a fatigue strength as the test data might seem to indicate. Powder-pressing techniques can produce better shaped fillets than machining or grinding can; and they also leave surfaces free from tool marks and other defects.

Damping properties of sintered parts are better than for equivalent compositions conventionally produced. For example, the sintered APM alloys have 1½ to 2½ times the damping capacity of wrought aluminum. Where fatigue loads are caused by random vibrations, the extra damping given by sintering can more than compensate for lower fatigue strength. "Damping Tapes for Vibration Control" (*PE—Jan* 25 '60, p 57) gives basic equations to calculate vibrational stresses in damped assemblies.

Hardness of sintered parts varies with the density as well as with the structure, and metal-powder parts show a wider hardness range, especially in the lower density materials. Sintered steels as a group do not follow the linear hardness-

GIVES CHEAPER PART



Cost Comparson for Steel Gear
Wrought vs Metal-powder Part

16 Teeth
8 Pitch
20° Pressure angle

Cost of individual powders, per lb.
Iron – 11.5 ¢
Copper – 45 ¢
Graphite – 40 ¢

Material	Cost per lb, ¢	Density, lb/cu in. (from chart)	For 1000 gears		
			Powder, cu in.	Weight of material, lb	Cost of material, $
Steel bar	8.5	–	–	36	2940
Iron-0.7C	11.44	0.238	71.5	17	21.20
Iron-5 cu	13.15	0.242	71.5	17.3	22.80
Iron-5cu=0.7C	13.09	0.204	71.5	14.6	19.10

strength relationships of wrought materials, but for a specific sintered composition, hardness generally increases with density. Uniform hardness from one area of a part to another is a better check for consistent properties than a single hardness reading.

COST COMPARISON

The powder-metallurgy techniques become more economical when they eliminate other forming, machining or joining steps. Cost of materials for any part should be compared on the basis of actual amount of raw material used rather than by weight of the finished part. While metal powders are more expensive for each pound of material, virtual elimination of scrap in the powder process usually reverses the cost picture. A sample comparison is given above for a small steel pinion. It shows how a costlier powder mix can give a cheaper material cost than by machining the part from a solid bar. It also shows how lower density needed by a stronger powder mix allows further materials savings and gives a part that is also easier to press because of the low compacting pressures that are required.

Sintered-metal parts have the additional advantage of giving consistent dimensions that allow handling by automatic equipment. From its inception the process was essentially an automatically controlled operation with low labor costs—compacting presses can produce as many as 6000 close-tolerance parts per hour with little attendance. (Average speed is 1000 to 1500 parts per hour.)

Cost of dies may mean a substantial initial investment. A normal set of tools is about $500 to $100. (They run from $250 for a simple die and $1000 to $2000 for a complex one.) But tool and die wear is low especially if tungsten carbide is used. Dimensions which are reproducible from run to run make this process even more adaptable to automatic manufacturing than automated machines that shape by cutting. These must compensate for the fast wear of the cutting edges.

EDITOR'S NOTE: For other articles giving additional design data on sintered powder parts:

How to Choose—Investment Casting or Sintered Powder, June 8 '59, p 86—Although investment casting and sintered metal powder seem competitive for making small mechanical parts, a closer look usually shows the choice is easy, once you know what the part must do.

For Many Thin Parts . . . Powder Metallurgy Can Compete with Stampings, May 11 '59, p 82—When powder metallurgy should be considered for many parts normally made from sheet-metal.

Slip Casting . . . Its Field Broadens, Oct 13 '58, p 84—Describes slurry method now moving into the metals field; tells how it stacks up against other metal-powder processes.

Design for Metal-powder Parts, Aug '57, p 183—Basics on designing shapes specifically for the cold-pressing process.

Submicron Metal Powders, June '57, p 182—Fine-particle sizes give sintered parts high strength and density.

Powder-metal Process and Part Design, Mid-Oct '55, p D-14—Influence of shape, size, tolerances and mechanical properties on selection of a metal-powder process.

High-strength Alloy-steel Powder-metal Parts, Mar '55, p 133—Hardenable alloy parts with strength, hardness and wear resistance approaching solid metal.

Powder-metal Bronze Bearings, Apr '54, p 182—Press fits, load capacity, running clearances and other pertinent design data to insure satisfactory service of self-lubricating bearings.

challenge . . .

the SPEEDUP in ENGINEERING

Everywhere you look, technology is expanding. The new capability and its absorption has increased the importance of engineering in our society. Here is a look at some of the trends that have developed so far, plus the author's views on what lies ahead.

JAMES F YOUNG, *manager*
Electric Utility Systems Engineering and Planning Operation
General Electric Co, Schenectady

Food, materials, the generation and application of energy—the basic elements of man's environment remain the same. But the scale is changing and I wonder if we realize how tremendous and far-reaching that change is.

The world depends as never before on engineering—it's that simple.

The impact of this responsibility will be deeply felt during the next 10 years. Its coming challenge is apparent in the logarithmic sweep of all the trend curves, in the frantic haste of our daily lives. Let's look at typical trends and try to guess what they will make of our future.

Increased Input

We have seen science beget science, and technology beget technology. And we have come to know technology to be as unpredictable as scientific discovery—and as virile. This suggests why most prediction up until now has been conservative. It also suggests that the "inputs" of information and effort are an important basis for estimating technological change.

One of these inputs is capital investment in education and in the work of science and engineering. The pace has been breathtaking. From 1776 to today we have spent $108 billions on R & D (Fig 1). Half of this investment was made since 1955—a scant five years ago. Even allowing for the inflationary erosion of the dollar, over half this country's R & D work has been performed within the decade just closed.

The dotted line shows, in anticipated dollar values, a projection of R & D expenditures to 1970. This rate forecasts an expenditure, during the 60's alone, of nearly twice as many dollars as in the prior 184 years history of the United States!

Some of the other indexes: R & D has been growing faster than Gross National Product, reaching about 3% in 1960 (Fig 2). Governmental support for R & D now exceeds private, or nondefense, R & D expenditures. In the last five years the number of private research laboratories has increased by half; the number of graduate students in science and engineering has risen over 80% in the last 10 years; and 90% of all scientists who ever lived are alive today.

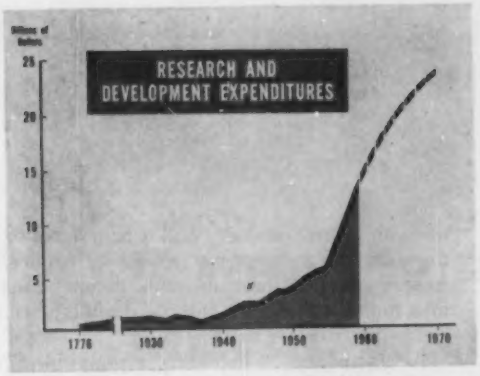
Increased Output

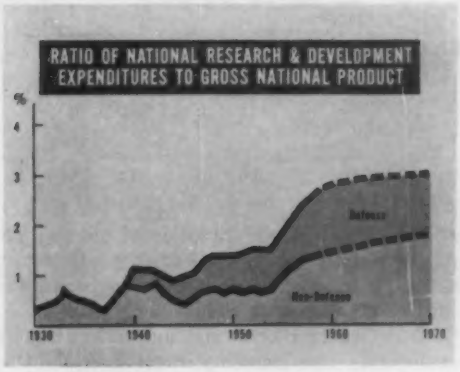
We may well question whether our R & D inputs have been used efficiently. How much has inflation in costs, and the maturity and complexity of technology, increased the input required for a given output?

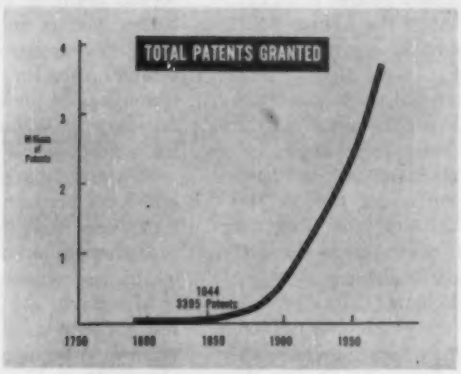
Nevertheless, the technological output has been tremendous. Look at the number of patents granted in the US. The first US patent was issued in 1790. By 1844, 3395 patents had been granted. The pace was so startling for those times that H. L. Ellsworth, then US Commissioner of Patents, said "We have already invented and patented all the ideas man could possibly have," and resigned with the recommendation that the Patent Office be closed. We now have nearly three million patents (Fig 3) and a conservative estimate for 1970 is 3,600,000.

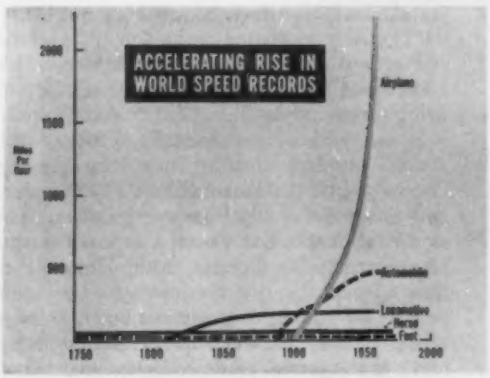
Another example is the explosive expansion in the production of technical literature. In the past year about two million technical magazine articles, 100 thousand technical books, and several hundred thousand R & D reports were published, totaling 60 million pages and 25 billion words. It would take a professional man 600 years or 14 working lifetimes just to read it all.

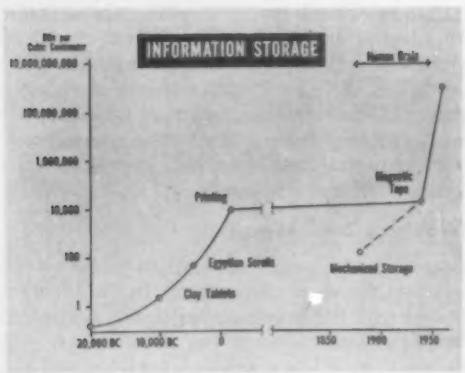
The pace is being speeded by a change in the classic relationship of science and engineering. For centuries discoveries were published, found their way to education, where they were taught to "engineers," who later applied them in product innovation.











More recently there has been an integration of science and engineering effort (with business objectives) aimed at speeding application of innovation. Men of science are more often reaching out to make applications of discoveries while engineers are reaching back for needed science. As a result, transistors were discovered in 1948 and appeared in hearing aids by 1953, in portable radios by 1955. Tranquilizers were discovered in 1954; there were 20 million users by 1957. Man-made diamonds were discovered in 1955—industrial production was well under way by 1958.

Increased Capability

Engineering capabilities are increasing at an accelerated rate. Look at the trend in speed records (Fig 4): In 1750 man's quickest method of travel was on horseback. In the 80 years between 1829 and 1909 the locomotive had no peer. In 1910, the automobile took the lead and, by 1921, the airplane. Manned rockets and space ships will hit the 18,000-mph range in the 60's.

A second illustration is in the increase in information storage density (Fig 5). In 20,000 BC it took one stone to supply one "bit" of information. Considering the stone to be about 8 cc in volume, this was a storage density of $\frac{1}{8}$ bit per cc. The introduction of clay tablets about 10,000 BC increased this storage density to 6 bits per cc. The Egyptian scrolls gave an additional boost to 60 bits per

cc by 5000 BC. With the invention of printing, around 500 AD, a plateau was reached at a storage density of 10,000 bits per cc. Then there was little significant change until the introduction of microfilm.

In January General Electric announced the development of thermoplastic tape recording where three million bits per cc have been recorded, with much greater potential. This storage density approaches that of the human brain and suggests, ultimately, the storage of the equivalent of an entire library at the engineer's desk.

Speed and information storage are just single aspects of the new technologies sprouting all over the place. In the 60's, new products based on electronics, for example, will include ultrasonic dishwashers, electronic ovens, automobile guidance, thermoelectric heaters and coolers, and a host of sensors and controllers. If past rates hold, the number of new electronic products developed in the next ten years will equal the number now available.

Another aspect, or dimension, of change is its direction. For example: in large size—toward the gargantuan turbine, radiotelescope, bridge, or skyscraper; or toward miniaturization—as in computer switching and memory devices; in sophistication—toward precision, purity, or structure, or toward adaptive and self-learning systems of control; in complexity—toward encompassing systems, like the steel rolling mill or the electric power system of today; or in integration of functions—as is promised by molecular electronics; in extreme environments—toward cryogenic temperatures or nuclear irradiation; and in reliability to cope with integration and complexity.

The Problems That Remain

Despite these advances more than a billion people today live on the verge of starvation. In the US the combination of high fertile acreage per capita, mechanization, and careful soil management has given us very efficient food production. While others have been less well blessed, there are fascinating new ideas on the horizon—like field lighting for controlling the length of the night cycle to obtain sequenced ripening of many foods; or cooled drinking water and cooled shelters now used experimentally for beef and dairy cattle, pigs, and chickens, to shorten summer fattening times by as much as one-half and to increase protein food output per unit of input by as much as 4:1. Further gains appear predictable from studies in genetics, to produce higher-yielding plant varieties, and in photosynthesis, to improve conversion of solar energy to food production, probably through use of the thousands of varieties of algae. These are engineering problems as much as they are agricultural or biological.

Water is beginning to need careful conservation. By 1970, the number of local areas facing a supply problem may be significantly large. Will weather forecasting and control reach the point when we can distribute water when and where needed? Will it be possible to boil water from the sea and produce rain where required? Or will freezing, electrodialysis and vapor decompression methods find important applications for desalting brackish water and water from the sea?

Air cleanliness is becoming a problem. Smogs are a regular event in Los Angeles and San Francisco. Manhattan receives an average of 250 tons of airborne "garbage" per square mile each month. An analysis of the complex chemical reactions of smog formation and the technology of prevention can be a significant task for the decade, even without contemplating the growing concern for radioactive fall-out.

Where will our power come from? More imports of oil? More production of oil and gas? Fluidization of coal? Extraction from shale oil? Nuclear fission? Or will the breakthrough occur in controlled fusion so in the 70's we can begin to rely on this inexhaustible source of energy?

Meanwhile the good old sun gives us 1000 times as much energy each year as we use. Will breakthroughs occur in energy storage, to take care of night-time use and cloudy days? How about the mobile use of solar energy for automobiles, which consume as much energy as all the electrical generating stations in the country?

The new energy conversion processes—fuel cells, thermionic and thermoelectric conversion, and maybe magnetohydrodynamics—appear certain to be applied by 1970.

In materials we are gradually becoming a "have-not" nation. Imports of iron have been growing steadily. Copper and the noble metals have a similar picture, posing new concern for export-import balances. This inclines us toward plastics and toward composite structures to use unique materials' properties to the limit of their development. It will also spur the search for new sources of ore, possible by mining of the ocean floors or by penetration of the earth's crust. Perhaps of greatest interest in materials is the increasing necessity for engineers to concern themselves with the arrangement of structure within a material, rather than with the arrangement of gross materials in structures.

Facing all this fabulous growth, and challenge, we have the mind and ingenuity of man. There is plenty of talent—more now than there ever was. But, amazingly, motivation seems to be lacking. In our past decade of abundance and affluence, our sense of values has appeared to deteriorate. We seem to have developed softness in a "something for nothing" climate. Have we lost the love of work—and view work as a distasteful interlude? Have we allowed government to take on more and more of the things individuals can do better themselves? Have we become materialistic and wasteful in our taste for chrome and trash?

Perhaps this is our greatest challenge of the 60's—to enlarge our values as much as we have enlarged our technological world.

8 ways to guard against METAL WHISKERS

When conditions are right, some metals breed tiny hairlike growths, which can cause short circuits or low impedance. Author tells when to be on guard; explains several possible remedies.

PETER C NOY, *technical representative*
Nicromatic Ltd, Toronto, Ont

Metal whiskers are crystal growths that resemble fine hairs. They occur most frequently on electronic parts electroplated with cadmium, tin, zinc, tin-zinc and tin-cadmium alloys. They are of increasing concern for two reasons: the present trend toward miniaturization of electronic units has meant narrowing the airgaps intended as insulation; lower and lower voltages are being used in such devices. The result is that these fine crystal growths, which can develop in large numbers, are causing failure by bridging the gaps and causing short circuiting or low impedance.

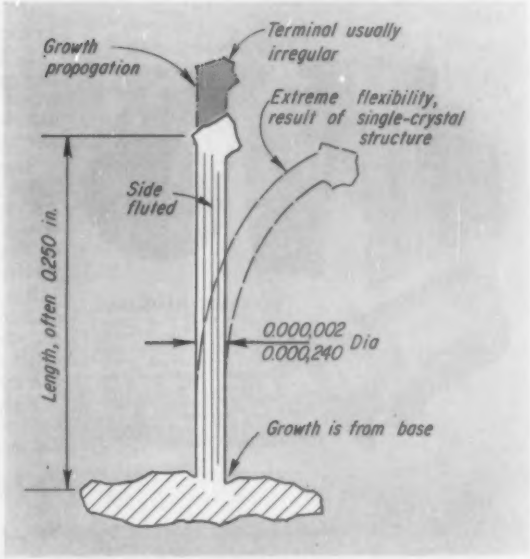
Considerable recent research has been done by the Bell Telephone Labs to find how these crystals grow and how to prevent them. There are several theories to account for their growth—one blames oxidation, another cites electrolytic causes—but most evidence now points to some sort of recrystallization process.

A concrete result of this research has been a better understanding of the nature of metal whiskers, and of the places where they can cause failure. The following summary tells when to expect whiskers to form and what preventive steps to take.

Conditions favoring growth

- Thin electroplate.
- Mechanical stress, (from screw or clamp pressure).
- Neutron bombardment.
- High humidity.
- Temperature of 125 F.

(continued on page 65)



CHARACTERISTICS OF METAL WHISKERS—resistance: about 50 ohms; current-carrying capacity, up to 10 ma (when approximately 0.000,080 in. dia and 0.125 in. long); temp coefficient of resistance, 0.0032/°C (at 20 C); optimum-growth temp, 125 F (51.5 C); growth rate, variable—years, to 0.001 in. per day; shape, usually straight, fluted.

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DENISON HydrOILics

This AUTOMATIC® truck handles hefty steel coil like a baby with smoother, safer DENISON hydraulic power

FLUID POWER

HYDRAULIC HANDLING *for steel coil. This "Skylift Giant" unit was developed by Automatic Transportation Co., Chicago—Division of Yale & Towne Mfg. Co. The "Coil Up-Ending Attachment" is powered by Denison Axial Piston hydraulic pumps.*

FLUID POWER for this "Skylift Giant" industrial truck—equipped with a special "Coil Up-Ending Attachment"—means it can easily heft rolls of coiled steel weighing from 10 to 40 tons. *Denison hydraulic power pays off here in smoother, faster, safer handling.*

In leading mills, these heavy-duty trucks speed handling and storage without damaging coils. The Coil Up-Ending Attachment enters the coil's inside diameter with a fixed ram . . . while the outside is gripped by a powerful hydraulic clamp. This clamp-and-ram design prevents "telescoping" of coils during handling.

Three hydraulic cylinders—powered by motor-driven Denison 3,000 psi Axial Piston Pumps—furnish lifting and clamping power. All three cylinders are connected hydraulically in parallel, which results in a telescopic-cylinder action—but has the added advantage of retaining equal force and speed throughout the stroke at constant pressure and delivery.

Result: Operator easily controls lowering speed at any level . . . and can inch the load up from extremely slow speed to maximum for which the flow control is set. *Safe, fast, smooth hydraulic control helps keep "Skylift" trucks continuously on-the-job . . . handling extra payloads.*

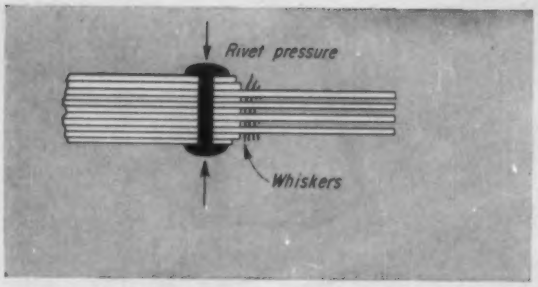
Here's the kind of job your Denison Hydraulic Specialist can help *you* do *now*. Call him in. See how Denison hydraulic power can help put *more payload into your equipment.*

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1194 Dublin Road • Columbus 16, Ohio

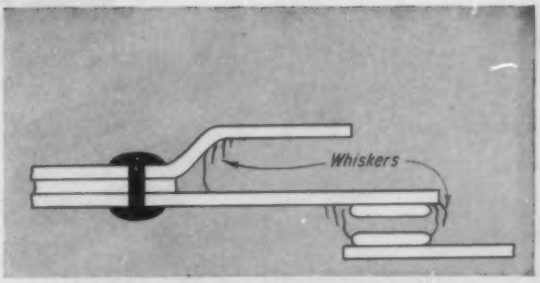
HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

DENISON
HYDRAULIC POWER

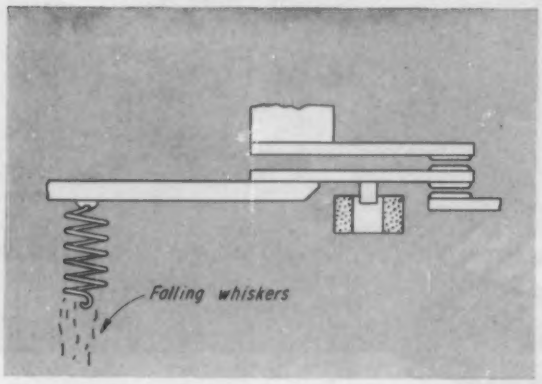
SUSCEPTIBLE DEVICES



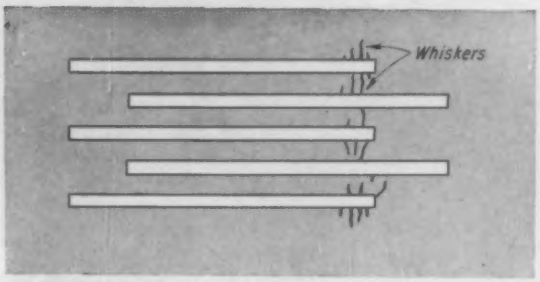
Electroplated terminal strips, where gaps are narrow and parts are stressed, favor growth.



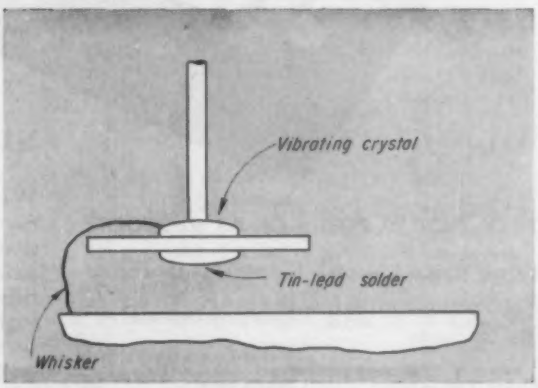
On relay contacts, dislodged or attached whiskers may cause complete failure of a relay.



Electroplated relay-springs, because of stressed condition, are susceptible to whisker growth. Dislodged whiskers may drop into sensitive circuits.



In electrical capacitors with air dielectric and plates of electroplated steel or brass, close spacing is easily bridged by metal whiskers.



In evacuated or inert gas-filled tubes, whiskers have been found. High-frequency vibration, e.g. near piezoelectric crystals, seems to cause or speed growth.

- High-frequency vibration, such as in tinned or soldered joints on piezoelectric devices.
- Base metal of brass and copper. (These seem more conductive to growth than steel.)

How to guard against whisker trouble

1. Learn when to expect whisker formation and double-check all such designs to make sure proper countermeasures are taken.
2. Substitute platings of nickel, chrome, copper, silver, gold, lead or tin-nickel.
3. Use unplated phosphorbronze, stainless, aluminum, brass, magnesium alloys or steel.
4. Use hot-tinned or hot-dipped zinc and cadmium in place of electroplate.
5. Where concern is marginal, use thicker electroplated coatings; or fuse electroplated coatings of tin.
6. Where bearing pressures are high, add solid insulating strips between parts where trouble might occur.
7. Prevent high humidity from reaching components.
8. Inert-gas atmosphere, oil, vacuum, duplex plating (tin over cadmium), fusing or reflowing of plating will not entirely prevent whisker growth; but interleaved paper (such as in capacitors) and heavy organic coatings will either prevent growth or stifle it sufficiently.

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures... and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

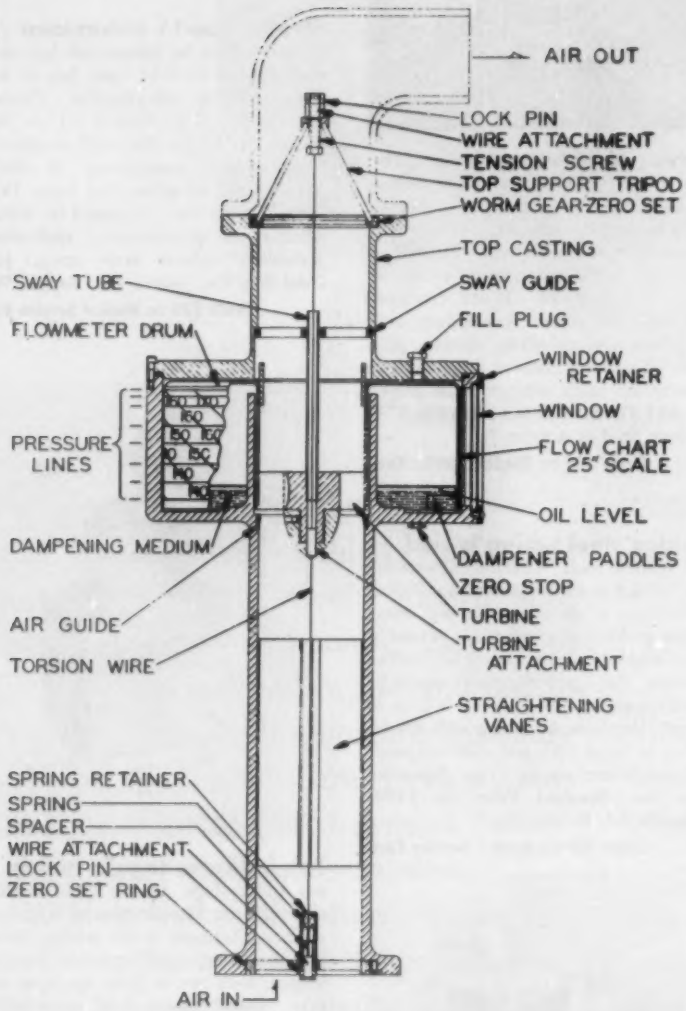
8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

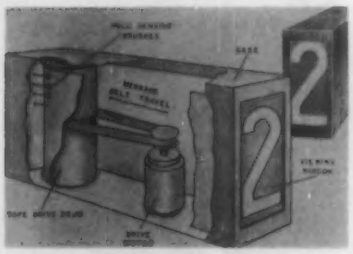
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Airflow meter . . .

offers direct readings for any airflow or liquid-flow measuring requirement, and can be made in small- or large-capacity units to measure air or liquid flows to nearly any limit at pressures up to 5000 psi. Flow meter, developed for use in the Air Force MB-1, has revolving drum-type dial, 25 in. in circumference, permitting direct readout of flows from 20 to 200 cfm at any pressure from 2 to 12.5 psi. Circular dial's long calibration range of 25 in., plus dampening by paddles turning in oil in drum reservoir, provide direct deadbeat readings at any point throughout circumference of dial. Dial is actuated by turbine wheel attached to spring wire stretched within vertical duct. As airflow velocity rotates turbine wheel, torque created is opposed by spring of wire, thus registering rate of flow on circular calibrated dial. Pressure drop through device is said to be less than $\frac{1}{10}$ lb. For extremely wide ranges of flow velocity, it is necessary to use more than one unit. Standard unit, $150.00. Delivery, 30 days. **Highland Engineering Co, 1740 Berkeley St, Santa Monica, Calif.**

Circle 300 on Reader Service Card



Digital indicators eliminate positioning errors . . .

and message-belt slippage by using position of holes in movable message belt in indicator to decode input signals from single-wire input, four-wire binary codes, or 10-wire input signal systems, operated manually or semiautomatically. Message belts are translucent Mylar, backlighted by cold cathode lamps and carry photoprinted digits, letters, symbols or complete multiword messages. Receipt of input signal initiates operation of permanent-magnet inductor drive motor. Motor drives message belt until preselected series of holes in belt are properly positioned under series of hole-sensing brushes. Motors are available in 6 to 220-v, 50 to 60-cps ratings. In standard, single-digit indicator with 2 x $4\frac{1}{2}$ in. visual character, cases are $2\frac{1}{8}$ x 6 x $9\frac{3}{4}$ in., for flange or recessed panel mounting. Standard, single-digit unit shown, $86 each for 1-10; $41 each for 5000 and over. Available from stock by Sept. with standard characters. **Electric Indicator Co Inc, Springdale, Conn.**

Circle 301 on Reader Service Card

Mineral-fiber-reinforced Teflon

is said to provide wire insulation with improved resistance to abrasion, plastic flow, cut-through and heat. Improved resistance to abrasion and cut-through is the result of orienting more than 90% of the fibers, which average about 1 micron dia and 500 to 1000 micron long, parallel to wire surface. Fiber-filled compound increases heat resistance of Teflon so that mechanical properties are reported to remain satisfactory for many hours, probably even weeks, at temperatures of 617 to 752 F. Even if Teflon burns away, protective mat of mineral fibers continues to prevent shorting of conductor. Fibers have long-term resistance to temperatures of about 2000 F. Offered as single-conductor wire, multi-

continued on page 68

conductor flat ribbon cable, and in shielded and coaxial conductors. Delivery, 2 wk. W L Gore & Associates Inc, 487 Paper Mill Rd, Newark, Del.

Circle 302 on Reader Service Card

Corrugated tolerance ring . . . is partially open ring made of steel strip, and is used to fix bearing in housing or wheel on shaft without need of interference fits or keys for limited torque transfer. Requires no close tolerances or machining. Patterns for basic shaft and for basic hole are each produced in six sizes of corrugation and in various widths. Fixtures up to 10 in. dia can be handled. Remains fixed even if aluminum housing expands under temperature more than bearing that is fixed therein. Samples for test purposes are available. Quantity production available from German maker until domestic production starts. For ¼ x ⅜ in. dia, 5¢ in lots over 5000. **Roller Bearing Co of America, Sullivan Way, West Trenton, NJ.**

Circle 303 on Reader Service Card

Switching galvanometer . . . with sensitivity of 1 microamp, minimum, full scale, is for use in control systems where energizing signal is too slight to energize conventional relays. Friction-free movement requires less torque to perform signaling operation. In systems using contacts, less closing pressure is needed to energize controlled circuit. Instrument utilizes taut-band meter movement. Pointer of taut-band meter carries moving contact that consists of small permanent magnet with closely controlled field and small gold contacts used for electrical contacts. Torque elements of instrument can be adjusted to control switching value. Energizes auxiliary relay, rated at 50 w, and can directly control a magnetic switch. **Hickok Electrical Instrument Co, 10514 Dupont Ave., Cleveland 8.**

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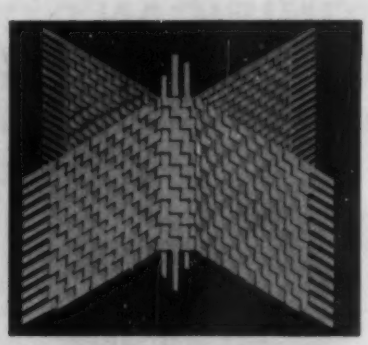
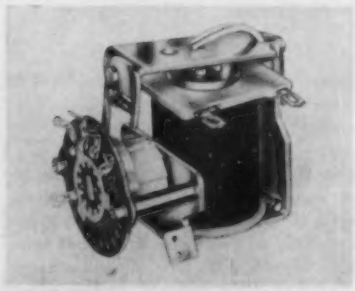


Woven-node honeycomb core is produced by three-dimensional weaving process that results in square cells. Woven nodes are said to exceed temperature limitations of bonded-node core. Exceeds all physical-property requirements of specification MIL-C-8073A. When combined with any of the popular resin systems, such as phenolics, phenyl-silane, silicones, polyesters or epoxies, material is reported to demonstrate nearly isotropic shear properties. **H I Thompson Fiber Glass Co, 1733 Cordova St, Los Angeles 7.**

Circle 305 on Reader Service Card

Welded steel tubing is clad with stainless steel. Cladding is mechanically bonded to welded carbon steel tubing in draw-bench operations for use where surface qualities of stainless are desired at cost considerably below that of all-stainless. Cladding has proved most successful where composite wall thickness is ⅛ in. or heavier. Available in tubing with diameters up to 3½ in. OD, and with composite wall thicknesses up to ¼ in. depending upon size. **Standard Tube Co, 24400 Plymouth Rd, Detroit 39.**

Circle 306 on Reader Service Card



Stepping switch . . . for sequence controlling, counting and totalizing, scanning, information storage and other switching operations can be furnished with two, three, four, eight or 12 poles, continuous rotation, for shorting or nonshorting steps. Available for operation on all ac voltages to 230 v. Voltage range is −15% to +10% of rated voltage. Nominal power is 20 v-amp ac min. Operating speed is 300 rpm. Rated at 1 amp at 115 v ac. **Comar Electric Co, 3349 W Addison St. Chicago 18.**

Circle 307 on Reader Service Card

Shorter size-11 servomotor . . . is also said to be lighter and less costly than BuOrd Mark-14 type, but to have same electrical characteristics. Operates in −67 to 257 F. Unit is 1.37 in. long and weighs 4.2 oz. Reported to eliminate terminal-board arrangement of BuOrd Mark-14 and to utilize lead wires. Housing is stainless steel. Designed for 400-cps airborne and ground-control applications. Immediate delivery from stock. **John Oster Mfg Co, Avionic Div, Racine, Wis.**

Circle 308 on Reader Service Card

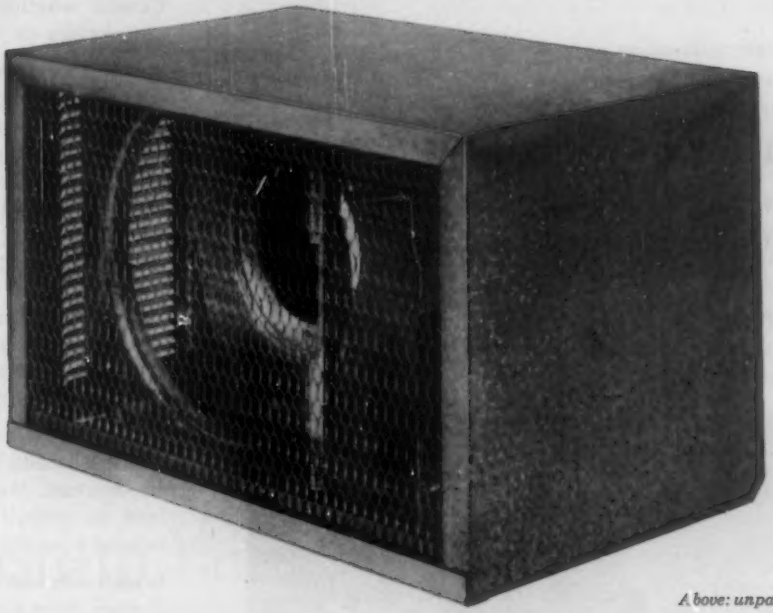
Tab-indicator toggle switch has paddle-shape tab of clear anodized aluminum for identification of toggle-lever position. Available in five models, including momentary- and maintained-contact versions with two or three operating positions. Require about 1 in. space behind control panels and weigh 1/14 oz. Each toggle operates two snap-action switches, each of which has two isolated SPDT circuits, UL-listed at 5 amp, 125 or 250 v. **Micro Switch, Div of Minneapolis-Honeywell Regulator Co, Freeport, Ill.**

Circle 309 on Reader Service Card

Fast-curing phenolic powders are for cold-powder automatic molding and preheat compression and transfer applications. Over-all curing rates are said to average 25% faster than those of conven-

continued on page 73

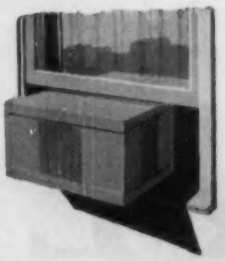
Better Products Through Better Methods and Steels



Above: unpainted air conditioner cabinet

How modern zinc-coated steel sheets keep air conditioners weatherproof—season after season after season.

When cold-rolled sheet steel formed the cabinets and special drawn base pans of air conditioners, they were primed and painted inside and out to protect them from constant exposure and functional moisture. Even so, corrosion often took hold around fastenings, louver edges and scratches.



Now that Weirkote continuous-process zinc-coated steel is used, the cabinet, louvers and chassis can be cut, bent and formed (even worked to the limits of the steel itself) without chipping or flaking the corrosion resistant zinc surface. When the outside paint finish is applied (primarily for decoration) the air conditioner has the double protection of a coating of paint and a coating of zinc assuring corrosion-free service for many years to come.

It's because of this weather-shedding surface, this superior formability that continuous-process zinc-coated steel is more and more the metal specified for air conditioning, heating and ventilating equipment.

A major supplier: Weirton Steel Company—producer of Weirkote continuous-process zinc-coated steel and many other steels that improve products, methods and profits throughout industry.

WEIRTON STEEL
Weirton, West Virginia

Weirton Steel is a division of **NATIONAL STEEL CORPORATION**

Weirkote will also be available in 1961 from National's Midwest Steel Division, Portage, Indiana

CIRCLE 69 ON READER SERVICE CARD

OIL SEALS

In Design Engineering

Proper choice of oil seal O.D. material assures longer, more positive bearing protection.

Steel O.D. or Rubber O.D. Oil Seals? Careful selection will assure proper performance on your application.

Rubber should be used only for soft housing materials such as zinc, magnesium or aluminum. In a molding process, rubber is shaped and sized by heat and pressure. These same factors exist when a seal with a rubber O.D. is applied in a steel housing . . . pressure is created by the normal press fit of the seal, heat by the location of the seal in the unit. Under these near-perfect molding conditions, the rubber O.D. seal re-forms to bore size, thus causing leakage at the bore.

Steel, on the other hand, should not be used in a housing made of soft material. In this case, the harder steel would tend to reshape the softer housing, causing a variety of problems.

In seals with both rubber and steel O.D.s, Garlock offers a complete line of high-quality KLOZURE* Oil Seals. They do a complete job of protecting bearings, sealing in vital lubrication, sealing out harmful dirt and foreign matter. During design, contact your Garlock representative for his recommendation on the best seal for your application. It costs no more to get his suggestions on the type of O.D., the seal material itself, the type of spring, and whether to use an assembled or bonded seal. Then, too, a new stocking program assures prompt delivery of KLOZURE Oil Seals when and where you need them. You can draw from over 2300 stock seals available from 180 national outlets, including one near you.

Find out more by calling the nearest of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada. Or, write for KLOZURE Catalog 30. Garlock Inc., Palmyra, N.Y.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products

*Registered Trademark

CIRCLE 71 ON READER SERVICE CARD→

custom tailoring costs less than "ready-to-wear"

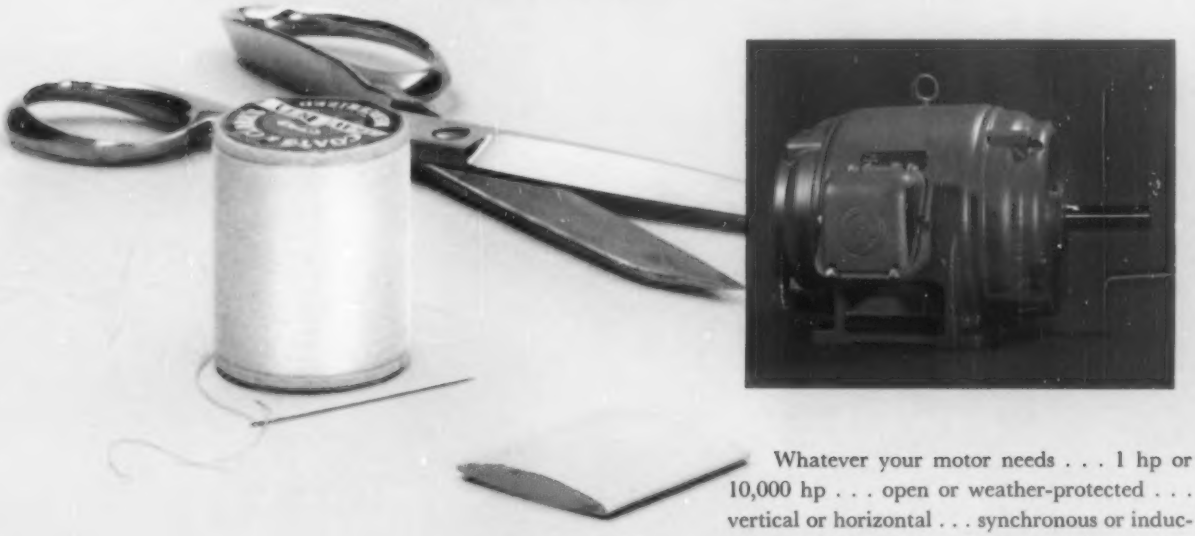
Buying an electric motor with "ready-made" insulation can be a costly luxury.

Motor operating conditions vary so widely throughout industry that Fairbanks-Morse insulation systems are *tailored* to actual operating conditions . . . not *standardized* to "the average".

"Ready-made" insulation systems are an "across-the-board" compromise with *average* operating conditions. When *your* case is the all-too-frequent exception, the compromise is costly.

Even in "hard to fit" cases we build motors rated, dimensioned and insulated to furnish unfailing power. Insulating materials are carefully tested, selected, treated and prepared so that insulation as well as motor enclosure is *matched* to the job. Entire insulation system is custom tailored to meet emergency overloads, temperature extremes, corrosive atmospheric conditions . . . whatever combination of factors affects motor life and performance of your *specific* operation.

This *flexible* application of varied insulating materials and processes "pays off" in low maintenance, uninterrupted production, prolonged service.



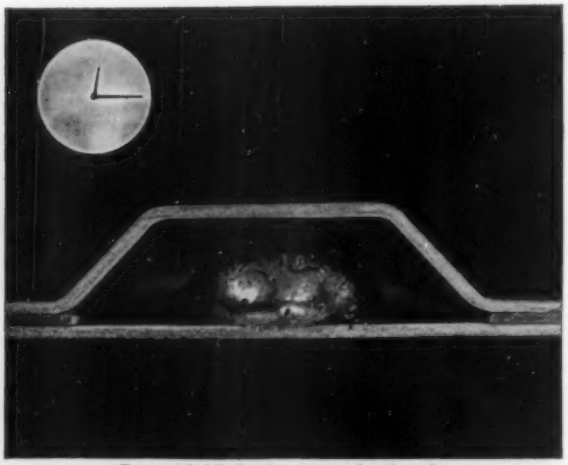
Whatever your motor needs . . . 1 hp or 10,000 hp . . . open or weather-protected . . . vertical or horizontal . . . synchronous or induction . . . AC or DC . . . Fairbanks-Morse builds it, builds it right, builds it to last. Get the facts . . . drop a line today to: Fairbanks, Morse & Co., Freeport, Illinois.

Fairbanks, Morse

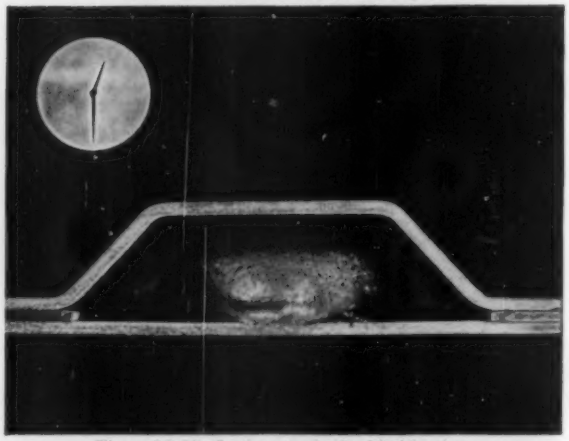
ELECTRICAL DIVISION

A MAJOR INDUSTRIAL COMPONENT OF **FAIRBANKS WHITNEY CORPORATION**

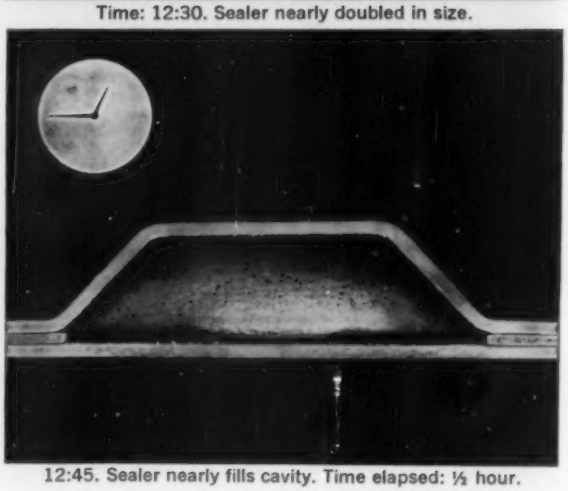
Positive way to seal irregular gaps and seams—3M Heat Expandable Sealers



Time: 12:15. Sealer enters heat cycle.



Time: 12:30. Sealer nearly doubled in size.



12:45. Sealer nearly fills cavity. Time elapsed: ½ hour.

You can simplify tough sealing jobs of irregular gaps and seams with 3M Heat Expandable Sealer EC-2117. When heated this liquid will expand 150% in volume and cure to a solid sponge rubber material to tightly fit the shape of the seam, affording a weather-tight, water-tight, dirt-tight seal.

EC-2117 is designed to expand and cure to a resilient sponge-like rubber which will adhere to most surfaces. It can also function as a weld-thru sealer which does not alter normal spot welding procedure, nor interfere with weld quality. EC-2117 adheres well to both clean and oily surfaces. Use it wherever irregular openings must be filled, or where seam width is not constant.

Let 3M Adhesives, Coatings and Sealers help speed your production, improve product quality. For free information, write on your company letterhead to: AC&S Division, 3M Company, Dept. SBS-70, St. Paul 6, Minnesota.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

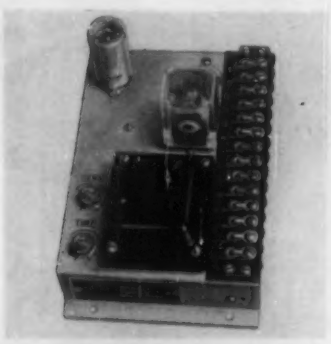
tional fast-cure powders. Phenolic molding powders are manufactured in standard industry flows and to 14-mesh grind. Available in preheat black, cold powder black and two-way brown. **General Electric Co, Chemical Materials Dept, 1 Plastics Ave, Pittsfield, Mass.**

Circle 310 on Reader Service Card

Silicone rubber coatings . . .

are said to have excellent resilience and dielectric strength. One, a thin rubber coating, is suited for cushioning fragile components or miniature assemblies against shrinkage during encapsulation, to minimize arc-over on open leads in electronic units, and to coat and impregnate glass-fiber cloth for use as a heat-resistant, insulated covering for cable. The second coating has foam-like structure, and is used as heat-barrier insulation for applications where thermal insulating coating is required. **Melpar Inc, 3000 Arlington Blvd, Falls Church, Va.**

Circle 311 on Reader Service Card



Adjustable delay in scanner relay . . .

permits light-beam to be interrupted repeatedly for intervals shorter than selected delay-time. This suits photoelectric scanner relay for such uses as monitoring movement of parts through handling systems and providing positive indication when parts fail to feed or when they jam up on moving conveyor. Delay can vary from 50 millisec to 1¼ sec. Various light-source/photocell combinations regulate scanning distance and use of direct light or proximity sensor. DPDT plug-in relay handles 8-amp noninductive load at 115 v ac. Unit connects to any 100-130 v ac line. **Farmer Electric Products Co Inc, 2300 Washington St, Newton Lower Falls, Mass.**

Circle 312 on Reader Service Card

Elapsed-time indicator . . .

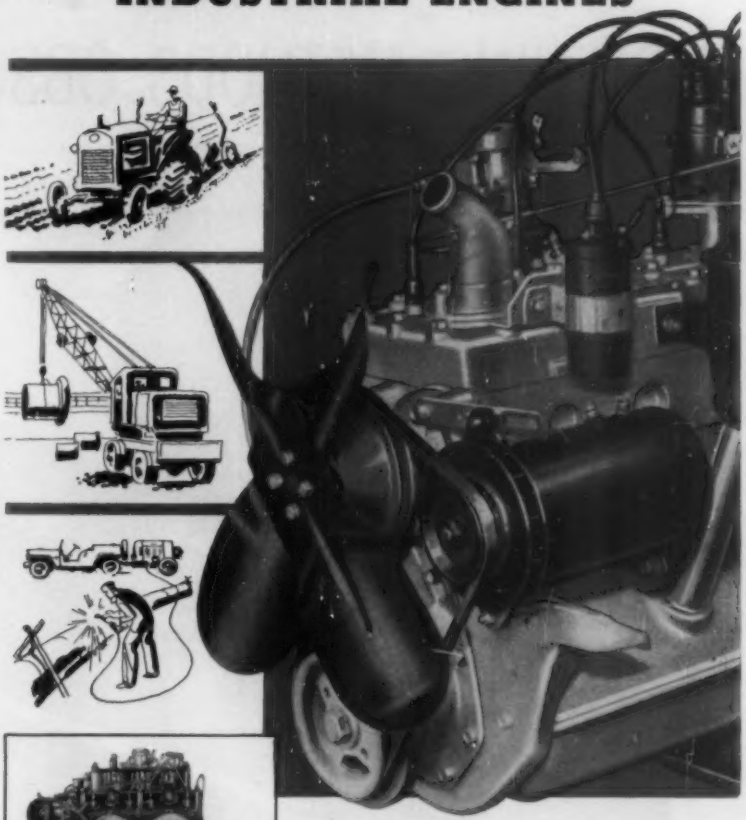
has range of 99,999.9 hr (minutes available on request) with min time indication

continued on page 76

MORE WORKING MUSCLE

'Jeep'® -6

INDUSTRIAL ENGINES



THE RUGGED 'JEEP' -4 ENGINES

Low first cost . . . economical performance . . . plus proven stamina. Two 4-cylinder designs deliver 20 to 55 continuous duty hp. World-wide availability of parts.

The most powerful 'Jeep' Engine of all. It's the high torque, heavy duty 'Jeep' -6 Industrial Engine. This tough 6-cylinder Engine develops maximum torque at 1200 rpm, and maintains all but 8% of this driving force right up to the limit of its continuous duty speed range. For rugged jobs requiring 30 to 65 continuous duty hp., here is an Engine with the *muscle* to handle it . . . fortified with Keypoint Engineering.

Write for specifications and prices.

KAISER WILLYS MOTORS

WILLYS MOTORS, INC.
Industrial Engine Dept.
Toledo, Ohio

Manufacturers of 'Jeep' -4 and -6 Cylinder Industrial Engines

HOW **LOXITE®** ADHESIVES CAN MAKE YOUR PRESENT FASTENING METHODS OBSOLETE

ELIMINATE WELDING
Loxite adhesives bond metal to metal faster, at far less cost.

ELIMINATE RIVETING
No preparatory drilling or punching; surfaces 100% smooth.

ELIMINATE STITCHING
Loxite streamlines the bonding of fabrics and leathers.

ELIMINATE NAILING
Fastening wood to wood, wood to metal, Loxite ends costly nailing.

From furniture to shoes, motor vehicle parts to jet bombers, Loxite adhesives are replacing mechanical fastening methods in ever more assembly operations every day. Loxite bonds metals, plastics, fabrics, wood, leather and ceramics to each other or to themselves.

You'll find the Loxite family of adhesives well worth investigating because they give you *far more fastening ability per pound, far less fastener bulk per job!* With these advantages, Loxite adhesives do almost any fastening job more swiftly and more economically—and with greater bonding strength—than mechanical fasteners.

LOXITE ADHESIVES SPEED PRODUCTION: Costly equipment and pre-assembly operations are eliminated; there are no holes to drill, punch, countersink, tap; assembly operations go faster and resist severest vibrations and other stresses.

IMPROVE EXISTING PRODUCTS: Better appearance, less weight with little or no design or tooling changes.

INVITE NEW PRODUCT DEVELOPMENT: Fabricate complex new shapes with ease and economy; leave desirable surface smoothness; absorb flexing stress.

ADVANCE PRODUCTION METHODS: Low-cost, lightweight Loxite adhesives are pioneering in new products thought impossible a few years ago; eliminate costly mechanical fastening methods such as welding, riveting, stitching, nailing, stapling, screwing, soldering; streamline all operations to ultimate in fastening simplicity and strength.

Your Loxite Sales Engineer can help *you*, too, greatly simplify and economize on your assembly operations. To get his trained counsel, without cost or obligation, fill out and send in coupon below.

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Firestone

XYLOS RUBBER COMPANY, AKRON 1, OHIO

A division of The Firestone Tire & Rubber Company

54-2

The Firestone Tire & Rubber Co.
Application Engineering Laboratories
Xylos Rubber Division
1200 Firestone Parkway
Akron 17, Ohio

Gentlemen:

We would like to have your suggestions on adapting Loxite Adhesive to our application. It is understood that the information specified below will be kept confidential and that our company will be under no obligation at all.

HERE IS A DESCRIPTION OF OUR ASSEMBLY PROBLEM. PLEASE MAKE RECOMMENDATIONS FOR A SUITABLE BONDING COMPOUND.

Materials to be bonded _____ *to* _____

Description and end use of finished assembly _____

_____

Present method of joining _____

Difficulties encountered with present method _____

_____

Mechanical stresses to which assembly will be subjected _____

_____

Temperature extremes _____ *to* _____

Vibration problems _____

Solvents to which assembly might be exposed _____

_____

Company _____

Street address _____

City _____ *Zone* _____ *State* _____

Signature _____

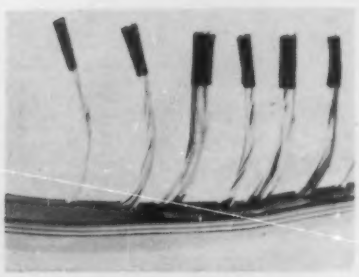
of $\frac{1}{10}$ hr. Six display wheels, black numerals on white, show elapsed time. Rated 115 v, 60 cps; 230 v, 50 cps; 230 v, 60 cps; or 24 v, 60 cps. Indicators cannot be reset and operate only when motor is energized. Measure $2\frac{5}{16}$ x $2\frac{13}{32}$ x $3\frac{7}{8}$ in. deep; can be surface or flush, top or bottom mounted. Running-time indicators list for $10. **Automatic Timing & Controls Inc, King of Prussia, Penna.**

Circle 313 on Reader Service Card

High-temperature shaft couplings

are made of $\frac{1}{16}$-in.-dia. flexible shaft core capable of operating in temperatures to 300 F. Flexible couplings can have formed squared ends or can have fittings attached. Square facilitates engagement for drive and also permits slight changes in length due to varying torques. Couplings are suitable for controls that must operate at temperatures too high for hydraulic controls and which must be flexible enough to take up movement in flexible members. **Stow Mfg Co, 426 Shear St, Binghamton, NY.**

Circle 314 on Reader Service Card



Tapered zipper tubing . . .

offers tight-fitting cable jacket for cables of decreasing diameters due to branchouts. Wires can be pulled through perforations of tubing to permit attachment to termination points. Supplied to customer specifications and can be ordered in colors matching all types of cable jackets. **Zippertubing Co, 752 S San Pedro St, Los Angeles 14.**

Circle 315 on Reader Service Card

Shock-resistant head and tail lamps . . .

for farm, construction or other off-highway tractors or equipment, offer no metal-to-glass contact in retention of beam element in lamp. Glass-beam element is held in place by heavy-duty neoprene ring. Beam pattern is locked in position at all times and 90° indexing, which permits using beam pattern in different positions is made possible by locator notches on inner diameter of ring. Available in $4\frac{1}{2}$- and $5\frac{3}{4}$-in. sizes in three basic types—one is pod type and others are flush mounting. **John W Hobbs Div, Stewart-Warner Corp, Springfield, Ill.**

Circle 316 on Reader Service Card

Adjustable-speed drives . . .

are dc motor drives employing adjustable autotransformers in combination with full-wave rectifiers to attain infinitely variable speed adjustments over wide range. Modular construction permits prewiring and prestocking of variety of chassis to meet different specifications. Available in size 1 for $\frac{1}{4}$ hp max and size 2 for $\frac{3}{4}$ hp max. Two other sizes are offered, with max ratings to 10 hp. **Cleveland Machine Controls Inc, 1155 Brookpark Rd, Cleveland 9.**

Circle 317 on Reader Service Card

Variable-speed drives . . .

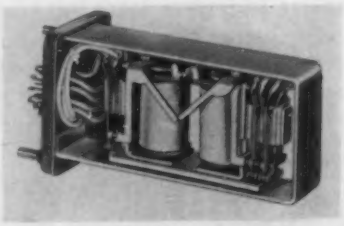
cover $\frac{1}{4}$ to $\frac{3}{4}$-hp range. Electrical drives use no tubes, have wide speed ranges with stepless adjustment from zero to full speed and utilize circuit breakers for armature protection. **Applied Technology Corp, 475 Fifth Ave, New York 17.**

Circle 318 on Reader Service Card

Size-8 geared servomotors . . .

are available with wide range of reduction ratios. Center-shaft gearheads can be provided in 28 ratios ranging from 7.62:1 to 1254:1 and eccentric-shaft gearheads can be provided in 25 ratios ranging from 7.62:1 to 903:1. Shafts can be plain, pinion, or of special design. Has no-load speed of 4.7 to 773 rpm min; stall torque of 1.8 to 20 in.-oz min; backlash of 30 to 45 minutes max. Rotation is clockwise and counterclockwise. Weighs about 2 oz. **Kearfott Div, General Precision Inc, 1150 McBride Ave, Little Falls, N J.**

Circle 319 on Reader Service Card



Miniature latch-in relay . . .

is enclosed unit requiring $2\frac{1}{8}$ x $1\frac{1}{4}$ in. panel space. Consists of two miniature relays mounted together. Armatures of two relays are mechanically interlocked so that energizing one armature latches it in and releases other. Coils and contact mechanisms of each relay are complete and entirely dependent of the other except for latch-in levers. Operating voltages or currents of two relays can be different. Available hermetically sealed or with removable cover for dc continuous or intermittent duty. **Magnecraft Electric Co, 3350Y W Grand Ave, Chicago 51.**

Circle 320 on Reader Service Card

Asbestos-nitrile gasket . . .

has been developed for high-temperature applications in place of compressed asbestos and other more expensive materials. Long-fibered asbestos and liquid-nitrile synthetic rubber are combined before sheet is formed. Said to have high resistance to oil, gasoline, and water; to have excellent recovery and conformability to flange surfaces; and to have high compressive strength. It has been tested to 250 F without damage. Available in rolls, sheets and finished gaskets. **Vellumoid Co, Sub of W R Grace & Co, Worcester, Mass.**

Circle 321 on Reader Service Card

Oil-free airpump

for industrial processes or machines requiring automatic pressure to 20 psi, has adjustable pressure switch that provides automatic cutoff at increasing pressures at 20 psi and automatic restart under decreasing pressure conditions at 18 psi. Rated pump capacity is 0.3 cfm of free

continued on page 78

This is a 1½" Teflon* hose, actual size, bending to

A DIAMETER OF 6¾" AT −65° F!

Impossible to produce? TITEFLEX did it, and only TITEFLEX has it! Industry's idea of what flexible Teflon hose in large diameters *can* and *cannot* do has changed overnight.

THESE ARE THE FACTS:

- Minimum bend radius is only 3½ times diameter! Available up to 2 inch diameter, lengths to 25 feet.
- It has all Teflon's important features: fatigue life sets endurance records... it's tough, friction-free, light, inert, highly resistant to corrosion and extreme temperatures.
- Teflon innercore is convoluted by exclusive process, and reinforced with TITEFLEX heavy-duty wire braiding.
- Seal faces pressure tight. Braid, innercore and fittings are made practically one by the TITEFLEX method.

Already Springfield "400" is in use for live steam, alcohols, methanol and corrosive fluids. New uses for the toughest jobs are found every day... how about your operation? Get a copy of our bulletin from your TITEFLEX Distributor (in the Yellow Pages). Or drop us a line.

titeflex

titeflex inc. springfield mass. PACIFIC DIVISION · SANTA MONICA · CALIFORNIA

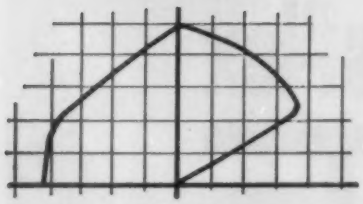
*T. M. of duPont
**T. M. of Titeflex, Inc., Pat. Pend.

STEWARD'S MAGNET FAMILY

High Energy Product

F-500

ORIENTED CERAMIC PERMANENT MAGNET



BH=3.5 x 10^6 G.Oe
Hc=2000 Oe Br=3900 G

APPLICATIONS:

LOUDSPEAKER MAGNETS MAGNETIC SEPARATORS AND OTHERS REQUIRING HIGH BH PRODUCT AND COERCIVITY

Look to D. M. Steward Manufacturing Company for all of your Ceramic Magnet requirements.

Write for F-500 brochure to:

D. M. STEWARD MFG. CO.
3640 JERROME AVENUE
CHATTANOOGA, TENNESSEE

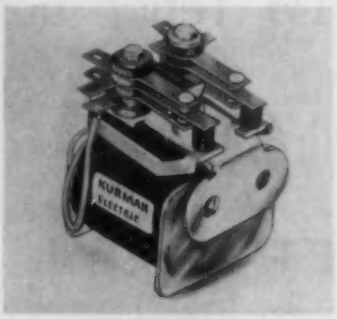
air delivery at 20 psi discharge pressure with standard sea-level inlet conditions. Pump displacement is 0.304 cu in. per revolution. The 4-amp, 60-cps, single-phase motor develops ⅛ hp at 3450 rpm. Weighs about 37 lb. **Lear Inc, P O Box 688, 110 Ionia NW, Grand Rapids, Mich.**

Circle 322 on Reader Service Card

Ductile copper plating . . .

is achieved by an electrodeposition of copper from a solution in which the additives are said to be stable and free of break-down products. The resulting copper plate is reported to be ductile, smooth and to have high covering power. Base metals to which this process is applicable include various types of steel, zinc, tin and alloys of these metals. **Seymour Mfg Co, Seymour, Conn.**

Circle 323 on Reader Service Card



Sensitive multipole relay . . .

requires operating power of 25 milliw min per pole. DPDT and 4PDT plate circuit relays are said to be smallest, lightest units offering self-wiping contacts. Contacts are rated 2 amp, 28 v dc/115 v ac for the 25-milliw version, 5 amp, 28 v dc/115 v ac for 50- and 100-milliw relays. Can be supplied with coil resistances of less than 1 to 20,000 ohm. Can also be supplied hermetically sealed and with polystyrene cover. Standard stock unit with operating power of 100 milliw per pole has price range of $5.30 through $7.40 for 1 to 10 units. **Crescent Petroleum Corp, 191 Newel St, Brooklyn 22, NY.**

Circle 324 on Reader Service Card

Broad-band RF filter . . .

for radio-interference reduction in all types of electrical and electronic equipment is said to provide up to 10:1 attenuation superiority over capacitors of comparable size. Three-terminal feed-through unit, similar to feed-through capacitor, utilizes inductance to increase insertion loss. The miniature filter, with resistance and capacitance incrementally distributed throughout inductance winding, has circuit arrangement that provides max RF attenuation with min line loading. Typical unit will attenuate interference 40 db at 1 mc increasing to 80 db at 10 mc and above. Attenuation characteristics do not change with changes in load. All units are shielded and hermetically sealed to comply with MIL-F-15733 and MIL-Std-202A. Available in 150- and 400-v dc ratings in two current ratings. Unit is offered in four basic models. **Devco Inc, East Longmeadow, Mass.**

Circle 325 on Reader Service Card

Thin ballbearing chassis slide

features quick disconnection and replacement of chassis-holding section of slide, and locking in extended position. Available in lengths to 36 in., slides have extension capability limited only by actual load carried. Vertically mounted, slide is 1.98 in. for unit handling weights to 75 lb per pr and 3.5 in. for unit handling to 200 lb per pr. Max width of three-member telescoping-slide series is 0.50 in. **Jonathan Mfg Co, 720 E Walnut, Fullerton, Calif.**

Circle 326 on Reader Service Card

500-va constant-voltage transformer . . .

is 60-cps unit with input of 95 to 130 v, and output of 115 v. Line regulation is ±1½%. Can be hermetically sealed for military applications. **Freed Transformer Co Inc, 1718 Weirfield St, Brooklyn 27, NY.**

Circle 327 on Reader Service Card

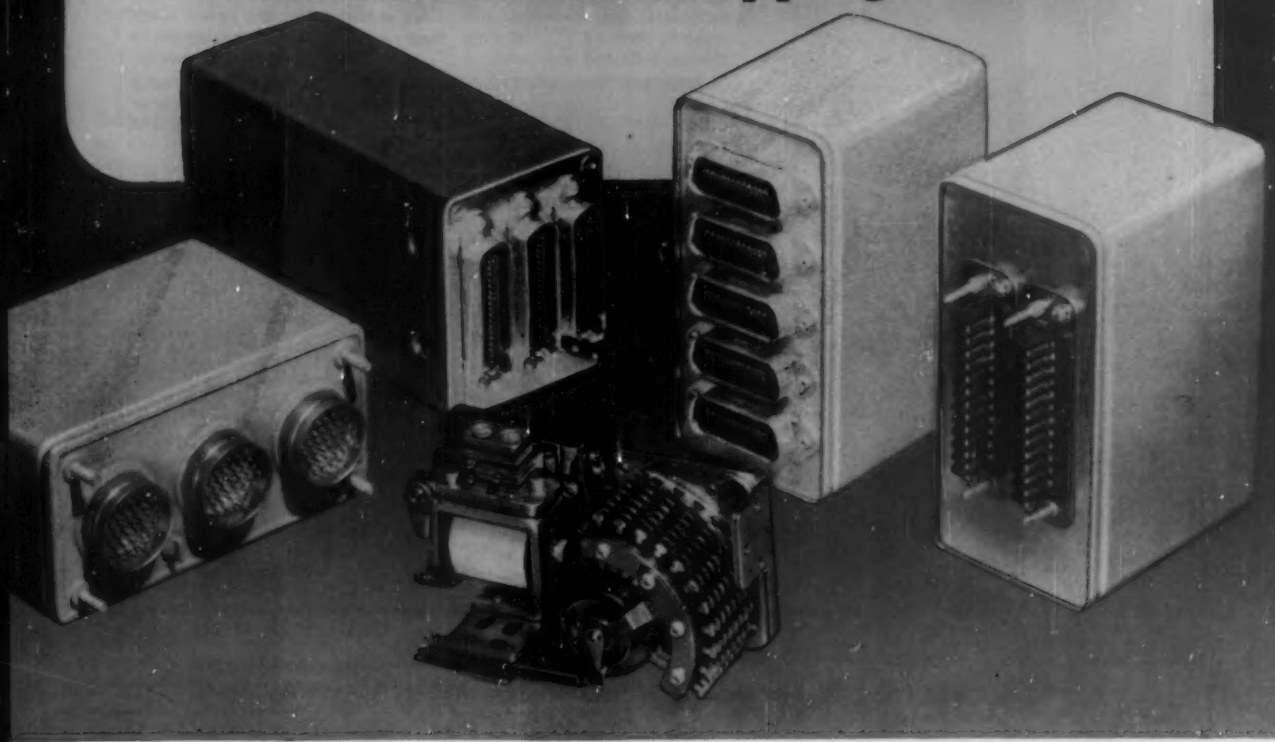
Miniature printed circuit connector . . .

has 10 dual contacts for total of 20 connections. Solder-lug terminations accommodate No. 22 AWG wire. Contacts accept 1.32-in.-thick printed circuit board or tape cable and grip over entire contact area. Coil-spring action grip permits use of undersized or oversized board tolerances

continued on page 81

NOW... from CLARE...

a new 10-Point Stepping Switch



for long life digital operation

Small, lightweight and capable of a minimum of over 100,000,000 operations,* the new CLARE Type 210 Stepping Switch is specially designed for digital operation. It is ideally suited as a component for sequence control, totalizing, sampling or single point selection. It transfers from Position 10 to Position 1 without special circuitry.

This new switch has all the improved features which have made the Type 211 an ideal component for complex switching requirements—long life, excellent capacity and freedom from maintenance. A wide variety of hermetically sealed and dust cover enclosures are available with terminals or connectors to suit the application.

Send for Bulletin CPC-6 for complete information. Address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois; In Canada: C. P. Clare Canada Ltd., P. O. Box 134, Downsview, Ontario. Cable Address: CLARELAY.

*with twelve 10-point levels . . . 300,000,000 operations with four 30-point levels (properly lubricated and adjusted).

CLARE

Relays and Related Control Components

ELECTRICAL DATA

OPERATING SPEEDS—Self-interrupt speed: 60 sps at 25°C on nominal voltage. Remote impulse speed: 30 sps at 25°C on nominal voltage with 66% make impulse.

OPERATE & RELEASE TIME—Operate time: 20 ms at 25°C on nominal voltage. Release time: 10 ms at 25°C on nominal voltage.

OPERATE & RELEASE VOLTAGE—Maximum pull-in at 25°C is 75% of nominal voltage. Minimum dropout at 25°C is 3% of nominal voltage.

BREAKDOWN TEST—1000v, rms, 60 cps, is standard.

COILS—Coil resistances for typical voltages are shown below:

VOLTAGE Vdc	1-8 LEVELS OHMS	9-12 LEVELS OHMS
6	1.5	1.5
12	6	6
24	24	20
48	100	70
60	150	100
110	600	400

MECHANICAL DATA

OVERALL DIMENSIONS—Length (maximum)—4-5/16 in. Height (1C interrupter, 1C O.N.S.)—2¾ in. Width—from 1-5/16 in. for 3 levels to 2-13/16 in. for 12 levels.

NET WEIGHT—From one pound for 3 levels to 1½ pounds for 12 levels.

BANK CONTACT—Standard is phosphor bronze. Also available are coin silver or gold plated phosphor bronze.

MAXIMUM BANK LEVELS & PILEUPS

Type of operation (points)	10	30
Bank levels maximum (electrical)	12	4
Interrupter springs	6	6
Off-normal springs	6	6
Number of ratchet teeth	30	30

WIPERS—Standard wipers are non-bridging phosphor bronze with coin silver and gold-plated phosphor bronze available in either non-bridging or bridging models.

PLAN HOLD

VERTICAL and ROLL FILES

Engineered to save time, space and money

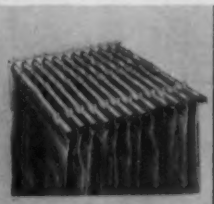
1. **Systematic filing** is practically automatic; you find what you want in seconds . . . reducing clerical time and overhead.

2. **Valuable plans** are fully protected; never dog-eared, mutilated or lost . . . saving more time and replacement expense.

PLAN HOLD Vertical and Roll Files come in fixed, mobile or portable units and security cabinets. See them at your engineering supply or office equipment dealer. Or write direct for illustrated catalog and price list to:

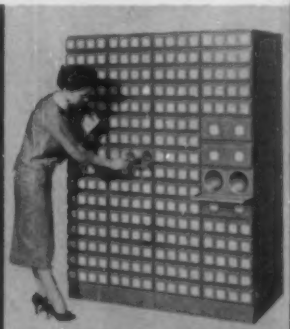
PLAN HOLD CORPORATION Dept. 60
5204 Chakemco St., South Gate, Calif.

Steel cabinets for vertical or roll files.



Wall mounted files for 1200 sheets in only 24 lineal inches.

Mobile Files speed use by several departments.



Roll File units stack as desired . . . for sheets up to 5' wide.

CIRCLE 204 ON READER SERVICE CARD

OHIO WELD NUTS

RH NUT
Thread Size 6-32 to ⅜-16

WF NUT
Thread Size 6-32 to ⅜-16

SF NUT
Thread Size 5/16-18 to ½-13

WW NUT
Thread Size 6-32 to ⅜-16

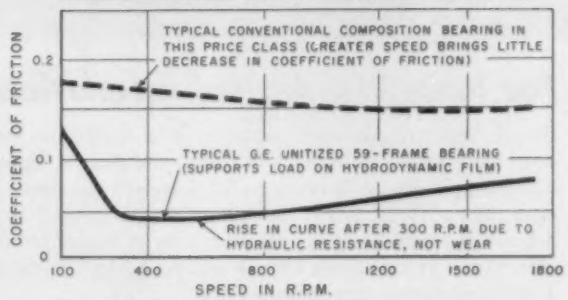
OHIO flanged weld nuts provide extra-long thread engagement and are ideal for assemblies requiring strong primary fasteners. They can also serve as spacers or bearing surfaces where required.

Samples and information furnished upon request.

The OHIO WELD FASTENERS Primary Fastener in Fastener Assemblies

THE OHIO NUT AND BOLT CO.
41 FIRST STREET BEREA, OHIO

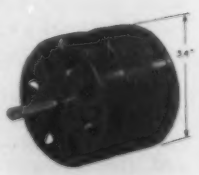
WEAR-FRICTION COMPARISON
GENERAL ELECTRIC VS. CONVENTIONAL MOTOR



New *Unitized** shaded-pole motor reduces bearing wear and noise

General Electric Unitized shaded-pole motors are designed to drive tape recorders, business machines, portable appliances, fans, and similar machines. A new lubrication system reduces bearing wear and noise. Thus, in normal operation, quiet sleeve bearings need re-oiling only once a year. These motors can be stud- or band-mounted at all angles. Available in open or enclosed models.

* Trademark of General Electric Co.



G-E Unitized motor. From 1/1000 to 1/15 hp, 1550 rpm, 4 pole.

FREE BULLETIN Write to Section 727-01, Schenectady 5, N. Y.

GENERAL ELECTRIC

CIRCLE 205 ON READER SERVICE CARD

CIRCLE 80 ON READER SERVICE CARD

while maintaining low contact pressure. Connector is 1⅞ in. long. Contact material is spring-temper phosphor bronze with gold plate over silver plate. Electronics Div, DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.

Circle 328 on Reader Service Card

2-in.-dia blowers . . .

are now available in different models with 400 cps ac, three-phase; 400 cps ac, single-phase; and 28 v dc motors. Employ motor speeds to 22,000 rpm. One model has no-stall characteristic performance curve with shutoff pressure of 6 in. water and free-air delivery of 32 cfm. This performance is reported to be obtained at relatively low decibel rating. Dean and Benson Research, Div of Benson Mfg Co, Kansas City 27, Mo.

Circle 329 on Reader Service Card

High-current thyratron . . .

is rated 10 amp, 1500 v peak inverse and forward voltage. Peak anode current is 120 amp. Designed for control applications requiring high current, it is said to be especially useful in motor-control applications as it permits thyratron control of larger motors than was previously possible. It is gas and mercury filled. Condensed mercury temperature limits are −40 to 194 F. National Electronics Inc, Geneva, Ill.

Circle 330 on Reader Service Card

Miniature thermostat . . .

is differential-expansion-type control with eight standard ranges up to 1150 F. Incorporates snap-action switch rated 5 amp, 125/250 v ac, 20 amp, 30 v dc. Available in open style or with NEMA 1 enclosure. Temperature settings are made with internal adjusting screw. Can be immersed in liquids, air or other gases. Burling Instrument Co Inc, 16 River Rd, Chatham, NJ.

Circle 331 on Reader Service Card

Automatic lead dispenser . . .

feeds lead to holder without handling. Spring-action feed is used. All 17 degrees of this company's drawing leads come packed in the dispenser. Koh-I-Noor Pencil Co, Bloomsbury, NJ.

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DESIGN LITERATURE

The Story of Engineering

Dr JAMES KIP FINCH. Doubleday & Co, 575 Madison Ave, New York 22. 7⅛ x 4⅛, 528 pp. $1.45. (paperback)

To the best of our knowledge, this is the first attempt to present a complete history of engineering. Books covering the history of science and technology could fill many shelves of a library, and a discussion of the socio-economic impact of science and technology through the ages could fill the remainder. But like most attempts to review the scientific advances of mankind, there is too much to say and not enough space to say it. This is the chief drawback of Dr Finch's mammoth undertaking.

In the introduction, the late Prof A. N. Whitehead is quoted, "within the last hundred years, a developed science and a new epoch has opened." A review of engineering during this "new epoch" would have given Dr Finch a far narrower area to survey, and one that could be handled more in depth. The term "engineer" is relatively new (in the old days they were called "mechanics"), therefore the story of engineering should be limited to our modern concept of the word. Granted that those chapters discussing the works of ancient Egypt, the Roman builders, and the Italian Renaissance encompass some remarkable feats of building know-how. But they deserve to be treated as a separate volume. On the other hand a book titled, *The Story of Engineering*, cannot hope to cover "electronics and automation" in 250 words or "the machine-tool builders" in three pages. By attempting to include too much (like chapters on civil and chemical engineering) Dr Finch has unfortunately included too little. It is also unfortunate that an encyclopedic book of this nature is presented to the reader without benefit of an index.—BAL

Polyester Resins

JOHN R LAWRENCE. Reinhold Publishing Corp, 430 Park Ave, New York 22. 5¼ x 7¾, 251 pp, $5.75.

From a level of 10 million pounds in 1950, polyester-resin production may top 160 million in 1959, 250 million pounds by 1965. This book is a comprehensive presentation of the booming unsaturated polyester resin industry. It covers all aspects from historic background, chemistry, curing mechanisms and manufacturing to techniques used in processing the resins for use in reinforced plastics, casting and coating applications. Uses for polyesters fall in a broad spectrum from boats to missile bodies, and the author presents them in concise form. Particular emphasis is given to formulating resins for special properties such as weathering and flame resistance. The chapter on coating applications is the most complete coverage available on this relatively new use for polyester resins. Appendix includes a tabulation of the basic characteristics of the standard resins manufactured by the major resin suppliers together with related reference material.

Standard Costs for Manufacturing

STANLEY B HENRICI. McGraw-Hill Book Co, 330 W 42nd St, New York 36. 7 x 10, 402 pp. $8.50.

Cost-reduction programs, which can take up much of everyone's time, should not be mere skimping on small items. These programs work effectively only if they are part of larger efforts that start with standard costs of manufacturing and carry savings through from inventory to the final product.

This book, part of the McGraw-Hill Accounting Series, gives details on how to set up a cost-accounting system for an entire plant. The established standard costs then become the base from which savings can be measured. The book is particularly useful in smaller plants where cost accounting is not separated from engineering.

Units, Dimensions, and Dimensionless Numbers

D C IPSEN, McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6 x 8½, 232 pp. $6.50.

The importance of mathematics to engineering is uncontested; but the importance of the dimensions that appear on the numerical results of practical mathematics is not so often appreciated. An understanding of units —how they may be manipulated, how they behave, and the insights they provide—is the aim of this book. It is addressed to those engineers who wish to increase the power of their familiar mathematical tools by a thorough understanding of the sense behind units and dimensions.

Not a compendium of tables listing standard units and conversions factors (these are available in any handbook), this book approaches the topic from the point of view that theory, rather than technique, is the basis for solving practical problems. It compares the rationale behind alternative units of mechanics (fps, cgs and mks systems) and discusses in detail the units of thermodynamics and electricity. This fundamental background in the first chapters prepares the reader for the practical techniques presented in the concluding chapters: similitude, dimensionless relations, dimensional analysis, and relations between geometrically dissimilar systems.

Fixed and Variable Capacitors

DUMMER and NORDENBERG, McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6 x 9, 288 pp, $10.

Covered are paper, mica, ceramic, glass, vitreous enamel, electrolytic, air, vacuum, and gas-filled capacitors. Consult it also for helpful information on general purpose, precision transmitter, trimmer, and special types of variable capacitors.

Other Books of Interest

Chemistry for Engineers

E Cartmell. Butterworth & Co (Canada) Ltd, 1367 Danforth Ave, Toronto 6, Ont. 5½ x 8¾, 172 pp, $5.

Intended as a background in the study of this subject by all types of engineers.

Electromagnetic Energy Transmission and Radiation

Adler, Chu, Fano. John Wiley & Sons Inc, 440 Park Ave South, New York 16. 6 x 9¼, 621 pp, $14.50.

Discusses electromagnetic waves and oscillations in one, two and three space dimensions.

Selected Semiconductor Circuits Handbook

Edited by S Schwartz. John Wiley & Sons Inc, 440 Park Ave South, New York 16. 6 x 9¼, 11 parts, $12.

Semiconductors

R A Smith. Cambridge University Press, 32 E 57th St, New York 22. 6 x 9¼, 494 pp, $12.50.

Discusses physics of semiconductors and briefly reviews their applications.

continued on page 85

Some Ideas

for your file of practical information on drafting and reproduction... from

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Papers, in their special way, are as different as people . . . and choosing the best paper for a specific job can be as difficult as choosing the best *person* for the job. Here at K&E, we try to do the work for you, by painstakingly determining precisely the characteristics required, then refining them to the point of excellence. Here are some good examples:

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Tracing Pads "To Travel"

Brilliant ideas often occur at random moments. For that reason, engineers on the move usually keep a tracing pad handy. But pads with soft, chipboard backing are of little use without a desk under them. That's why all K&E tracing pads are backed with sturdy bookbinder's board – the same tough board found in any high-

priced, permanently-bound library volume. Wherever you are you're assured desk-firm support with a K&E pad. Another plus – the sheets are bound in by a gummed edge for neat and easy removal. Available in a wide variety of grid patterns and sizes, with plain or imprinted sheets (standard headings), K&E book-bound, gummed-edge tracing pads are perfect workmates for the "portable" professional.

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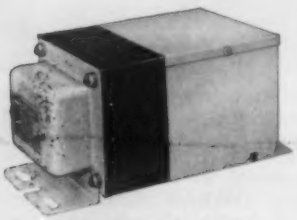
WHICH CONSTANT VOLTAGE STABILIZER MEETS YOUR NEED?

This compact stabilizer design occupies a minimum of space and is especially adaptable as a component in electronic devices where output voltages must be maintained ±1% of normal. Available in ratings of 15, 25, 50 VA.

Input voltage: 95/130
Output voltage: 120; 6.3



For applications requiring steady-state voltage for laboratory use or electronic circuitry this heavy duty design is available in the following stock ratings and voltage ranges.

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Input voltage: 95/130; 190/260; 190/260
Output voltage: 120 120 240

This unit has been designed to provide instantaneous response to voltage fluctuation in large loads. Voltage output regulation between no load and full load is constant regardless of input voltage. Current limiting protection under overload conditions.

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Output voltage: 120; 120; 240

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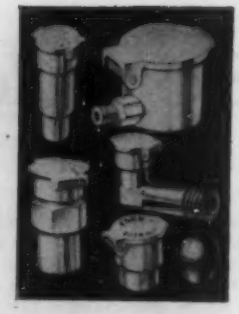
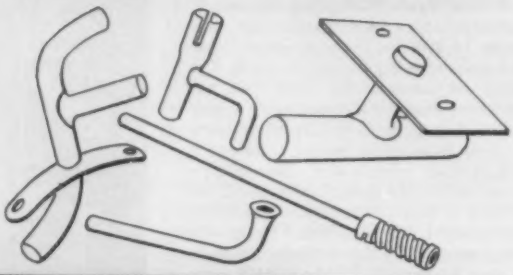


METAL TUBE FABRICATION



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Fluidization and Fluid-particle Systems

F A Zenz, D F Othmer. Reinhold Publishing Corp, 430 Park Ave, New York 22. 6 x 9¼, 513 pp, $15 trade, $12 text.

Discusses both theory and practice of fluid-particle technology, as applied in processing and other industries.

Mechanisms: Analysis and Design

P H Hill, W P Rule. Allyn and Bacon Inc, 150 Tremont St, Boston 11. 8½ x 11, 17 pp, 75¢.

ASTM Standards on Metallic Electrical Conductors

American Society for Testing Materials, 1916 Race St, Philadelphia 3. 6 x 9¼, 353 pp, $3.60 members; $4.50 others.

ASTM Standards on Rubber Products

American Society for Testing Materials, 1916 Race St, Philadelphia 3. 6 x 9¼, 1024 pp, $7.80 members, $9.75 others.

ABSTRACTS FROM THE LITERATURE

Magnetic Flow Measurement

Fluid-flow measurement by magnetic induction is simple in principle, but gives rise to some quite-difficult practical problems, which are discussed. A system is described which uses a suppressor containing only transistors, thermistors and other solid-state electronic components.

"Some Problems of Magnetic Flow Measurement," I. C. Hutcheon, Research and Development Dept, George Kent Ltd. Instrument Engineer, April '60, George Kent Ltd, Luton, Bedfordshire, England.

Digital Actuators

The growing importance of digital techniques for computation and control has led to the introduction of a complete line of digital actuators. These actuators can be operated directly from digital computers, digital-type remote control stations, or programers. Seven types are illustrated.

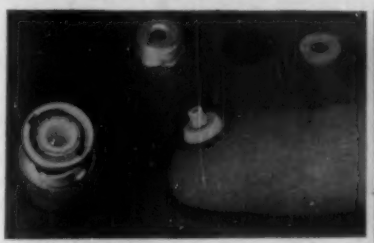
"Digital Actuators," T. Gizeski, Ferguson, Hille & Associates, Inc. Instruments and Control Systems, Nov '59, 845 Ridge Avenue, Pittsburgh 12.

Stainless Under Rapid Heating and Loading

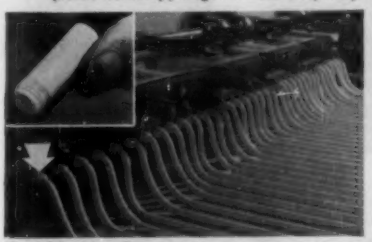
Rapid tensile and short-time creep properties are presented for several commercially available stainless steel and nickel-base sheet alloys (including Type 304, PH 15-7 Mo, Inconel and Nimonic). Specimens were heated to test temperatures of up to 2000 F within 30 sec. Tensile determinations

continued on page 87

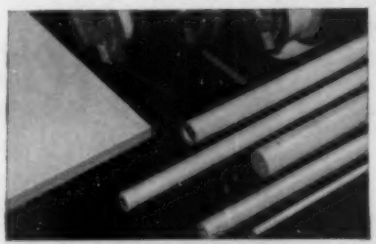
Design with versatile, POLYPENCO® Teflon* TFE shapes



Electrical Insulators
POLYPENCO TFE insulators in coaxial cable connectors are chosen for insulation over a wide range of frequency, operable in temperatures to 250° C. Permits small, lightweight, weatherproof design.
(Photo courtesy, Dage Electric Co., Inc.)



Food Machine Components
Machinery for making pretzel sticks utilizes extrusion dies machined from ⅜" diameter TFE rod. TFE's non-adhesive, low friction surface provides easy extrusion and smooth end product. TFE does not affect edible materials as it is odorless, tasteless, non-toxic, non-corrosive and steam sterilizable.
(Photo courtesy, Reading Pretzel Machinery Corp.)



Take advantage of Teflon's unique characteristics in your design. But don't risk inferior quality. Specify *Polypenco!* Design and engineering help on any industrial plastics problem is as near as your telephone—and yours without obligation.

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Large bearing of FLUOROSINT† TFE-fluorocarbon composition, a TFE base material with outstanding wear life and dimensional stability, has successfully operated at 450° F. for one year. Running without lubricants, FLUOROSINT prevents galling of shaft and failures experienced with metallic bearings previously used.

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POLYPENCO TFE seal fits between steel electrode and cover of a steam dial vaporizer. Seal is unaffected by boiling water with various mineral contents. Low friction surface permits easy turning of dial. POLYPENCO TFE shapes are resistant to virtually all chemicals.
(Photo courtesy, The DeVilbiss Co.)

**DuPont Reg. TM*

†*Polymer Corporation trademark*

ROD
Diameter: ⅛" to 7¼" in various lengths
TUBING
O.D. ½" to 12"
I.D. ¼" to 6⅛" depending on O.D.
SHEET
Thickness: 1/32" to 2"
Sizes: 12" x 12", 24" x 24", and 48" x 48"
TAPE
Thickness: .001" to .125"
Widths: ¼" to 24"
Ten fade-proof colors
SPAGHETTI TUBING
AWG sizes 30 to 0.
Thin and regular wall thicknesses
Ten fade-proof colors for coding
THIN WALL TUBING
I.D. ⅛" to 1"
Wall thickness: .030" to .050"
ROUND AND SQUARE BEADING
Round: Diam. .030" to .150"
Square: .020" to .156" across the sides
Rectangular and Square Bar also available

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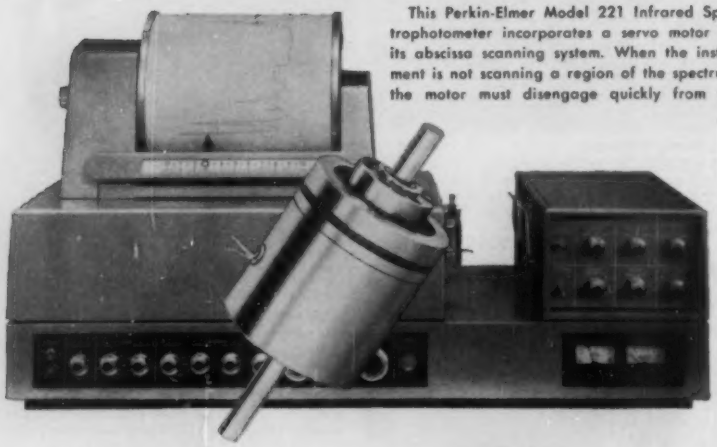

This Perkin-Elmer Model 221 Infrared Spectrophotometer incorporates a servo motor for its abscissa scanning system. When the instrument is not scanning a region of the spectrum, the motor must disengage quickly from the Littrow mirror drive and recorder system in order to allow the fastest possible abscissa run-back.

Perkin-Elmer chose a SIMPLATROL (Fixed Field) Clutch for this highly critical automatic function. Says Perkin-Elmer, "The Simplatrol Clutch is well suited for this application because it combines small size and high torque transmission with high quality at moderate cost."

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This new AGASTAT meets the environmental requirements of MIL-E-5272A. Built to withstand the rugged conditions of missile and aircraft applications. Lightweight—less than 15 ounces. Space saving—4⅝" tall . . . 1 13/16" wide . . . 1½" deep. Adjustable, with time delays from .030 to 120 seconds. Choice of operation for energizing or de-energizing. For complete specifications, write Dept. A37-726.

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Small solenoid valves that fill a BIG order

Conduit-type Master-mite. Grommet-type also available.

Designed to meet the need for positive-acting tight-seating valves for use on wide variety of media, including oxygen, hydrogen, acetylene, etc.

Two Types:
Conduit type and grommet type. Port sizes 1/8" and 1/4" NPT.

Ten orifice sizes:
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Pressure to 540 psi.

Small, but with more strength in the Marsh manner. Coils never overheat. Entire assembly leak tight. Remarkably quiet operation. Cleanable without breaking connections. Used in any position. Bodies either brass bar stock or 18-8 stainless steel. All moving parts stainless. Underwriters' approved for use on oxygen and hydrogen and as safety valves.

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CIRCLE 209 ON READER SERVICE CARD

were made at a strain rate of 0.1 in. per in. per sec. Creep properties were determined at tensile stresses that caused rupture in times ranging from 1 to 30 min.

"Strength of Structural Alloys Under Rapid Heating and Loading," Kattus (Southern Research Institute) and McDowell (International Nickel). ASTM Preprint 71. American Society for Testing Materials, 1916 Race St, Philadelphia 3.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 89.

MINIATURE LOCKNUTS—Catalog, 36 pp. Dimensional information and drawings on line of miniature locknuts and gang channels. Kaylock Div, Kaynar Mfg Co, Inc, Box 2001 Terminal Annex, Los Angeles 54.

Circle 340 on Reader Service Card

DISK SPRINGS — Handbook, 40 pp. Covers characteristics of disk springs, computation, application information and tables of all standard sizes of Schnorr disk springs. Karl A Neise Inc, 404 Park Ave South, New York 16.

Circle 341 on Reader Service Card

RESINS FOR RUBBER AND RUBBER-BASED ADHESIVES—Booklet S-79, 16 pp. Presents properties and functions of resins for use in compounding rubber and in formulating rubber-based adhesives. Much of the information, including a two-page summary of properties, uses, compatibility and solubility is offered in tabular form. Schenectady Varnish Co Inc, Schenectady 1.

Circle 342 on Reader Service Card

GLOSSARY OF COMPUTER TERMS —Booklet, 24 pp. Defines 82 terms, which have emerged in the process of building and utilizing industrial-process computers. Definitions are intended to make computer language more intelligible to the layman. Minneapolis-Honeywell Regulator Co, Industrial Div, Philadelphia 44.

Circle 343 on Reader Service Card

ELECTRICALLY OPERATED VALVES—Bulletin 91024, 20 pp. Gives descriptions, specifications, features, flow charts and dimensions of two-, three- and four-way electrically operated valves. Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.

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BRAZING TECHNIQUES—Booklet, 24 pp. Describes brazing techniques on all commercial brazeable metals and alloys. Specific solutions to common brazing problems are answered. All-State Welding Alloys Co Inc, 249-55 Ferris Ave, White Plains, NY.

Circle 345 on Reader Service Card

MAGNETIC CLUTCHES AND MECHANICAL DIFFERENTIALS—Catalog 63, 48 pp. Dimensions, specifications and prices of stock magnetic clutches and mechanical differentials. Sterling Precision Corp, Instrument Div, 17 Matinecock Ave, Port Washington, NY.

Circle 346 on Reader Service Card

THERMOCOUPLE ASSEMBLIES AND PRESSURE SEALING GLANDS —Specifications, characteristics and prices of thermocouple fittings, pressure sealing glands and thermocouple accessories. Conax Corp, 2300 Walden Ave, Buffalo, NY.

Circle 347 on Reader Service Card

INDUSTRIAL TEXTILE FIBERS — Brochure, 52 pp. Covers wide range of industrial applications in which fiberglass materials can be used. Contains sections on continuous filament yarn, treated yarn, staple fiber textile materials, cordage and sewing thread, and other types of fibers. Explains how fiberglass is made, includes a textile fiber comparison chart and a section describing fabrication of fiberglass materials. Owens-Corning Fiberglas Corp, General Offices, Toledo 1, Ohio.

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CERAMIC-INSULATED WIRE — Pamphlet, 20 pp. Outlines many of the pitfalls that must be avoided if components are to be operated successfully in 800 to 1200-F range. Divided into three parts, which cover physical and electrical properties of insulation, information on conductors and potting, sealing and termination. Secon Metals Corp, 7 Intervale St, White Plains, NY.

Circle 349 on Reader Service Card

RESILIENT MOUNTINGS AND MOUNTING SYSTEMS—Bulletin 905, 8 pp. Includes general design, application and performance information for 22 product series. Lord Mfg Co, Erie, Penna.

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HIGH-TEMPERATURE EPOXIES — Booklet, 8 pp. Describes five high-temperature epoxy-resin formulations for service in 450 to 500-F range. Two formulations are potting compounds; three are adhesives. Epoxylite Corp, PO Box 3397, South El Monte, Calif.

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CHART DRIVE—Catalog, 10 pp. Presents descriptions, features and performance information on multispeed chart drives, accessories, strip chart recorders. Application data includes chart showing all eight chart speeds provided by each model, ordering instructions and photos of installed units. Insco Co, Div of Barry Controls, Hollis St, Groton, Mass.

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CYLINDER-OPERATED SHEAR-SEAL VALVES—Catalog COV 60-61, 8 pp. Ratings, dimensions and specifications of valves available in four-way, three-way and shutoff flow patterns. Barksdale Valves, 5125 Alcoa Ave, Los Angeles 58.

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ROTARY-HANDLE CIRCUIT BREAKERS—Bulletin 1425, 8 pp. Covers line of rotary-handle circuit breakers from 15 through 800 amp, including features and their uses. Federal Pacific Electric Co, 50 Paris St, Newark 1, NJ.

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MECHANICAL VACUUM PUMPS—Bulletin 8-15, 6 pp. Features, construction and dimensions of line of oil-sealed rotary vacuum pumps. Consolidated Vacuum Corp, 1775 Mt Read Blvd, Rochester 3, NY.

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TOP-LAY ELECTRICAL CONTACTS AND STRIP MATERIAL — Brochure CON-11, 4 pp. Lists some of the types and properties of precious and base metals that can be combined in top-lay strip as bimetal or trimetal. Compares design configurations of conventional staked, brazed or welded assemblies with alternates manufactured by top-lay method. General Plate Products Group, Texas Instruments Inc, Metals & Controls Div, 34 Forest St, Attleboro, Mass.

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URETHANE COATINGS — File 1-60, folder. Series of 12 clear urethane coatings are described in information file. Chart provides general, physical, chemical and mechanical properties for each coating. B B Chemical Co, Cambridge, Mass.

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TEFLON-INSULATED WIRE AND CABLE—Bulletin, 4 pp. Covers construction and dimensions of series 100 and 120 hook-up wire. Philadelphia Insulated Wire Co, Moorestown, NJ.

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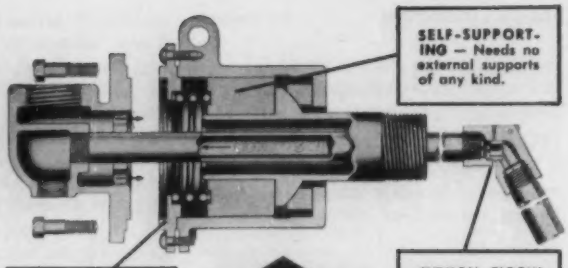
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FILLER METALS—Selection chart, 4 pp. Parent metal combinations of wrought alloys currently recommended for welding are indicated on table, together with acceptable filler-metal alloys for each combination. Aluminum Co of America, 743 Alcoa Bldg, Pittsburgh 19.
Circle 361 on Reader Service Card

GAS-FLOW COMPUTER—Data sheet 7.08, 4 pp. Describes analog computer that automatically and continuously measures and records mass flow on recorder. Minneapolis-Honeywell Regulator Co, Industrial Div, Wayne and Windrim Aves, Philadelphia 44.
Circle 362 on Reader Service Card

EPOXY PELLETS FOR ENCAPSULATION USE – Bulletin 3, 4 pp. Discusses advantages of epoxy pellets for use with electronic components; variety of pellet compounds available; and various epoxy packaging techniques, all illustrated. Epoxy Products, 137 Coit St, Irvington, NJ.
Circle 363 on Reader Service Card

TECHNICAL-DATA PREPARATION—Folder, 4 pp. Describes company services in preparing technical publications for aircraft, rocket and missile, and electronics manufacturers. Genge and Assoc, 1502 E Colorado St, Glendale 5, Calif.
Circle 364 on Reader Service Card

POLYCARBONATE RESIN – Folder CDC-375, 4 pp. Presents typical applications in the electrical and electronics industries and lists properties. General Electric Co, Chemical Materials Dept, 1 Plastics Ave, Pittsfield, Mass.
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INDICATING BELLOWS METER – Specification S224-1, 4 pp. Describes characteristics of mercuryless bellows-meter body with 6-in. dial indicator. Minneapolis-Honeywell Regulator Co, Industrial Div, Wayne and Windrim Aves, Philadelphia 44.
Circle 366 on Reader Service Card

ULTRAPURE SOLDER PREFORMS – Eulletin Z-103, 2 pp. Lists compositions and melting points of 33 typical alloys available as preforms. Also lists specifications on sizes, along with tolerances. Accurate Specialties Co Inc, 37-11 57th St, Woodside 77, NY.
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SINGLE-SEATED, SPLIT-BODY CONTROL VALVE—Data sheet 101, 2 pp. Shows construction, accessories available and specifications of Series LB control valves, ¾ through 6-in. sizes. Conoflow Corp, 2100 Arch St, Philadelphia 3.
Circle 368 on Reader Service Card

INFRARED DETECTOR PREAMPLIFIERS—Bulletin TB-1300-60, 2 pp. Descriptions and specifications of two preamplifier models for use with infrared radiation detectors. Servo Corp of America, 111 New South Rd, Hicksville, NY.
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GENERAL-PURPOSE RELAYS—Bulletin 99, 2 pp. Specifications and general characteristics. Artisan Electronics Corp, 171 Ridgedale Ave, Morristown, NJ.
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POST-FORMING-GRADE LAMINATED PLASTIC—Bulletin 3.1.15, 2 pp. Covers characteristics, properties and dimensions of material, which has crepe-paper base so that it can be drawn and formed. Taylor Fibre Co, Norristown, Penna.
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EPOXY-ENCAPSULATED MINIATURE MOTORS—Bulletin 1105, 2 pp. Describes line of 1¼-in.-dia hysteresis-synchronous ac motors. Globe Industries Inc, 1784 Stanley Ave, Dayton 4, Ohio.
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INFRARED-RADIATION DETECTORS—Bulletin TB-1300-1, 4 pp. Describes static and dynamic characteristics of thermistor bolometers. Includes diagrams, curves and useful formulas. Servo Corp of America, 111 New South Rd, Hicksville, NY.
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PIN-SPLICE ENDLESS BELTS—Catalog sheet, 1 p. Grades, dimensions and prices of pin-splice endless belts. Dodge Fibers Corp, Hoosick Falls, NY.
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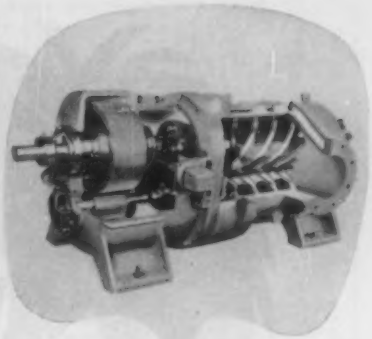
LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

MILITARY COMPONENTS – Catalog 50A, 36 pp. Presents US military specifications covering those components manufactured by Ohmite. Specifications are concerned with fixed- and adjustable-power resistors, precision resistors, rheostats, tantalum capacitors and relays. Ohmite Mfg Co, 3679 Howard St, Skokie, Ill.

SEMICONDUCTORS—Catalog, 12 pp. Includes basic specifications of line of VHF transistors. Also lists and gives specifications of germanium PNP and NPN audio, computer and switching transistors; germanium and silicon reference and power rectifier types and photodiodes. Amperex Electronic Corp, 230 Duffy Ave, Hicksville, NY.



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321—Asbestos-nitrile Gasket

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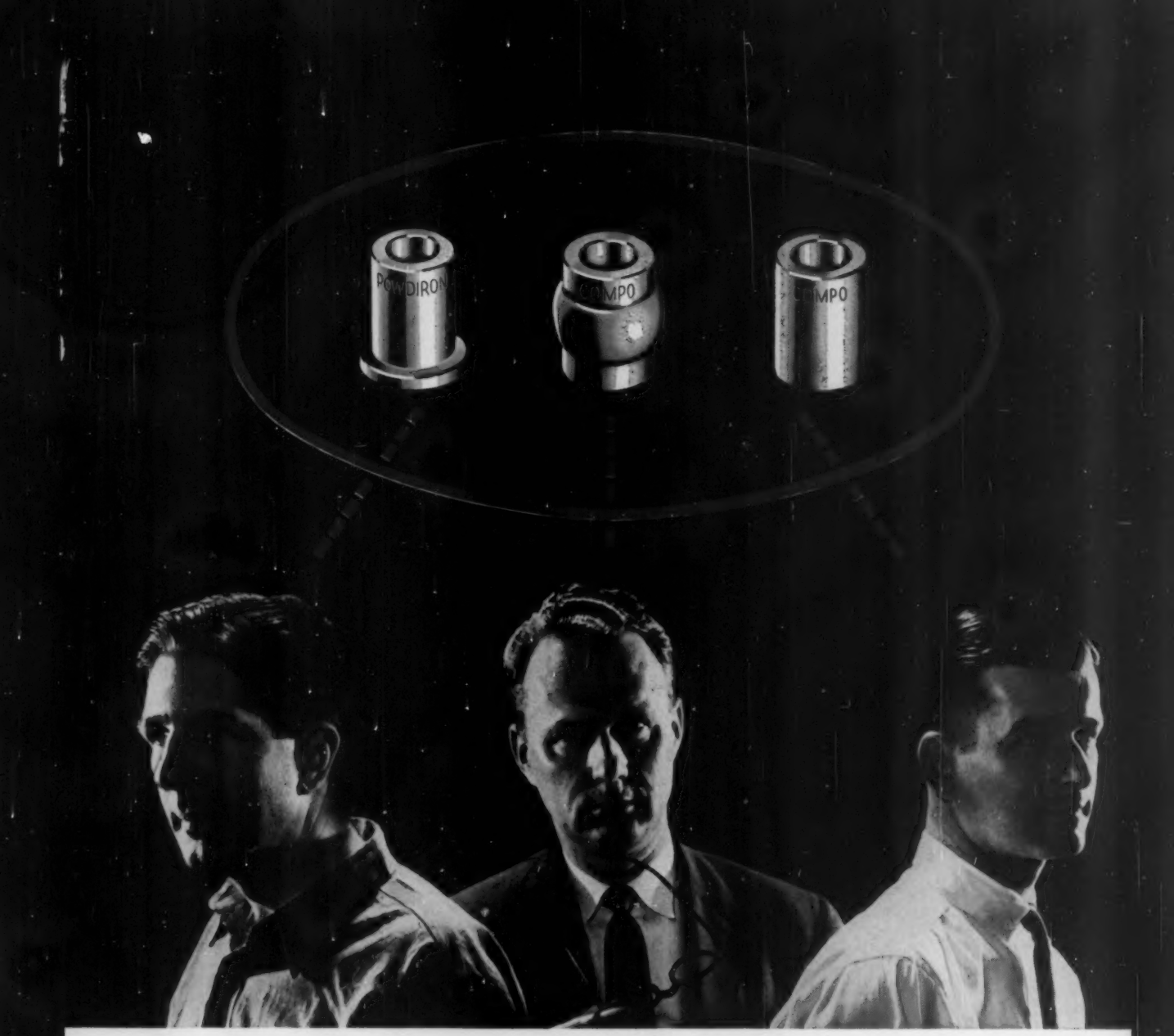

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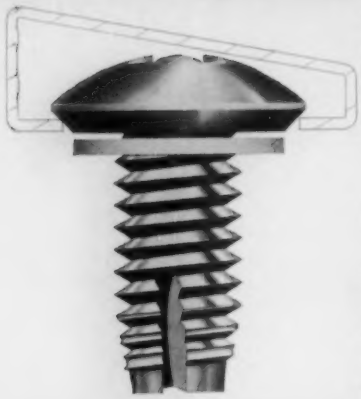

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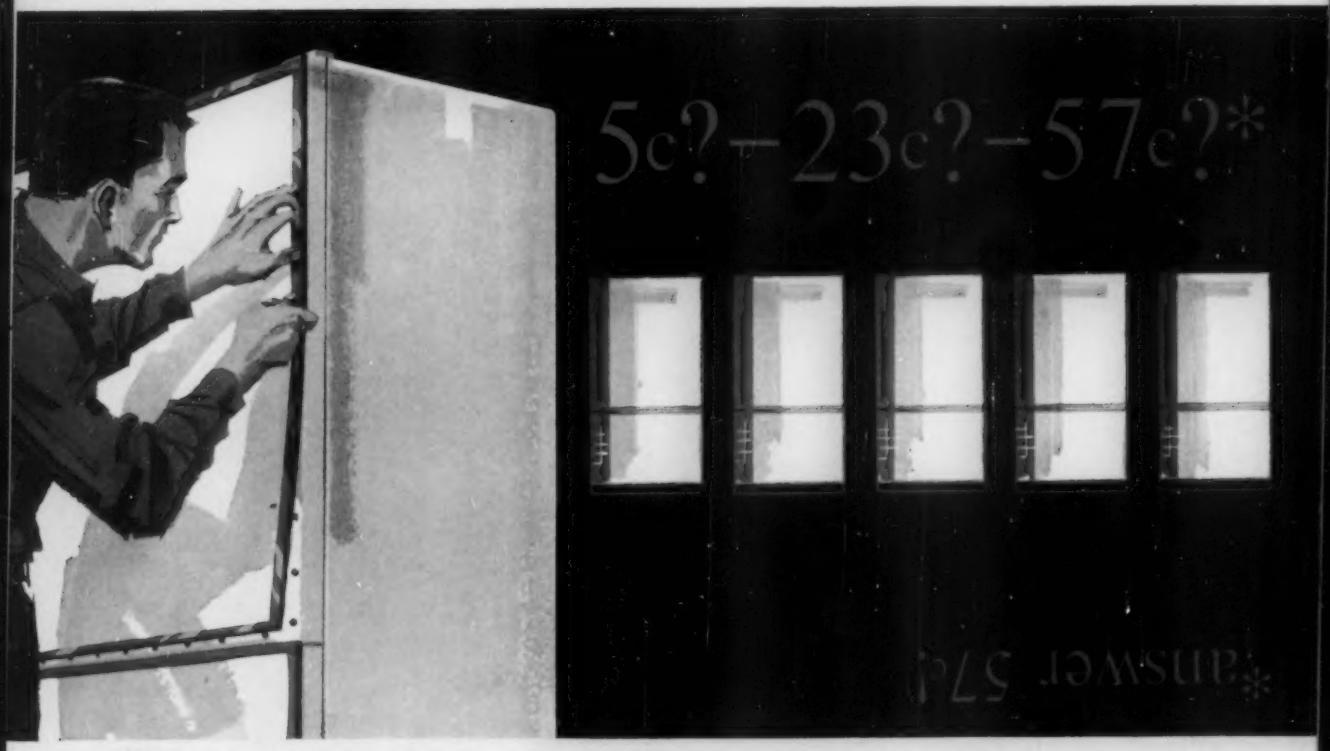

Ideas like this are important to you whether you make refrigerators or not. This one is typical of Shakeproof ingenuity in research and development that daily creates new ideas for industry . . . ideas to improve product performance, to speed assembly operations, to lower total costs. It represents the kind of creative engineering characteristic of Shakeproof designers and engineers who are available to visit your plant, to study your assembly methods and problems and to design ingenious new fastenings for your specific application.

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